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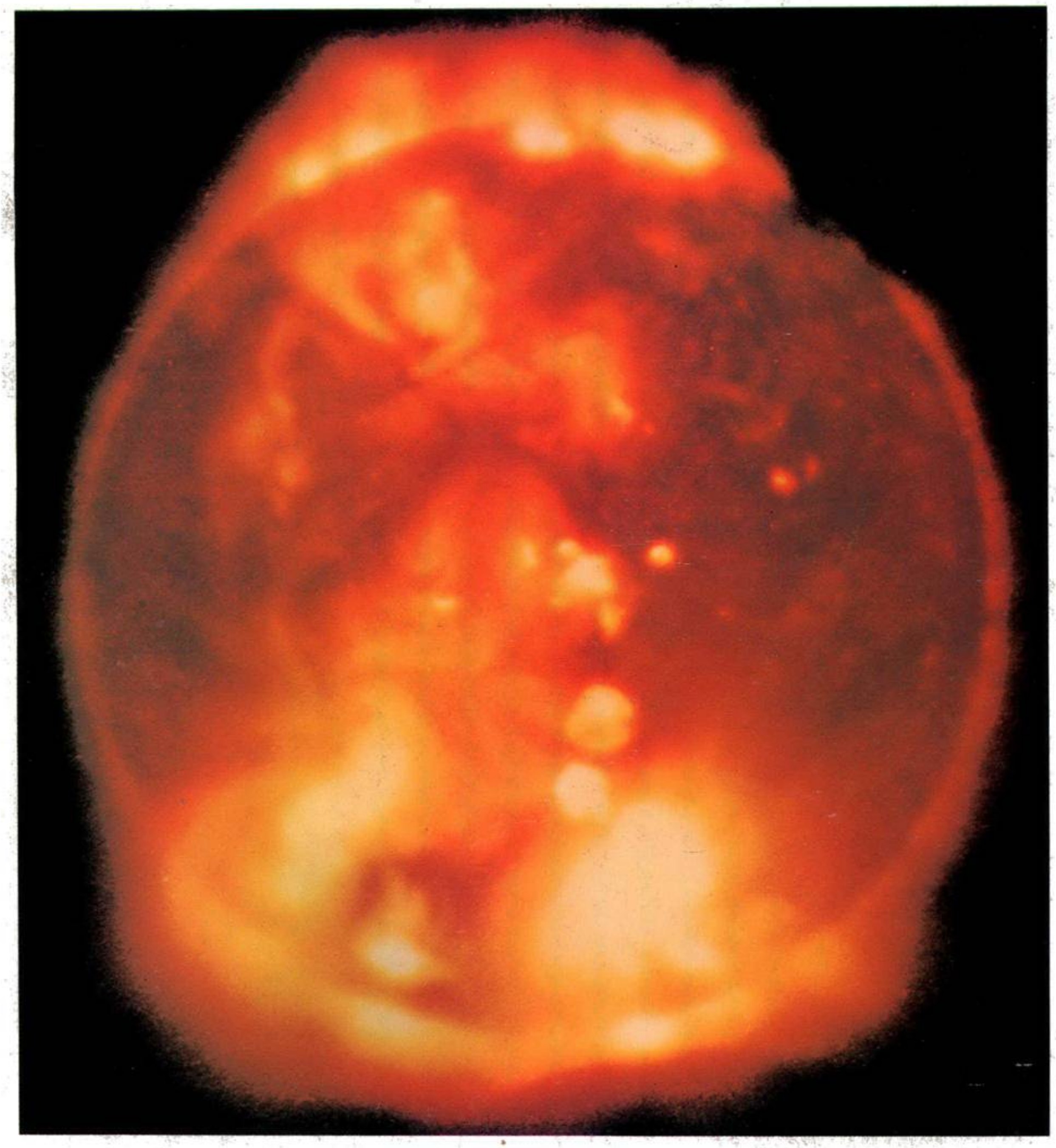

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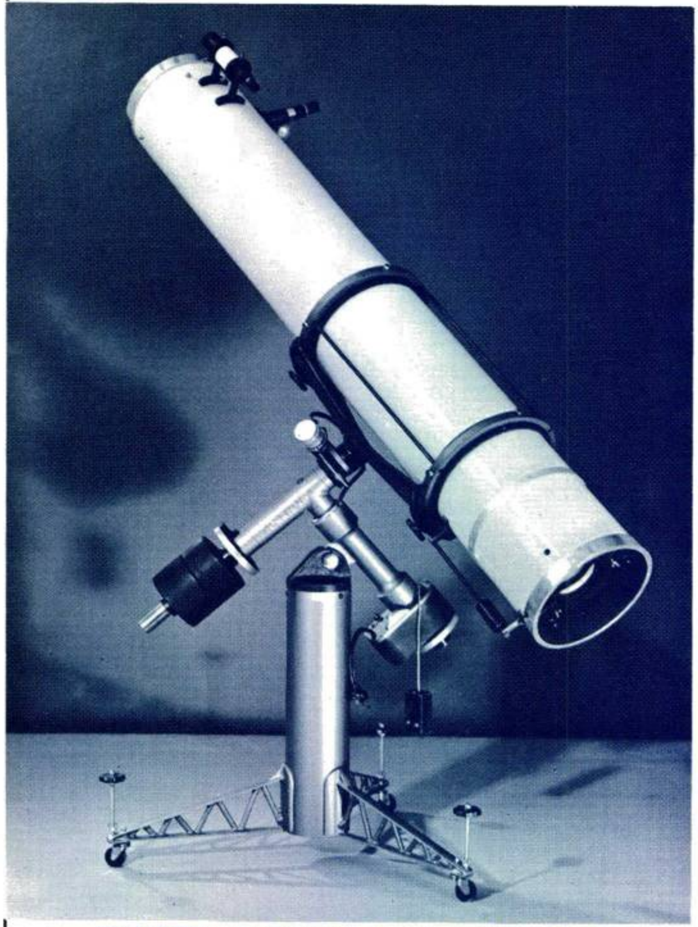

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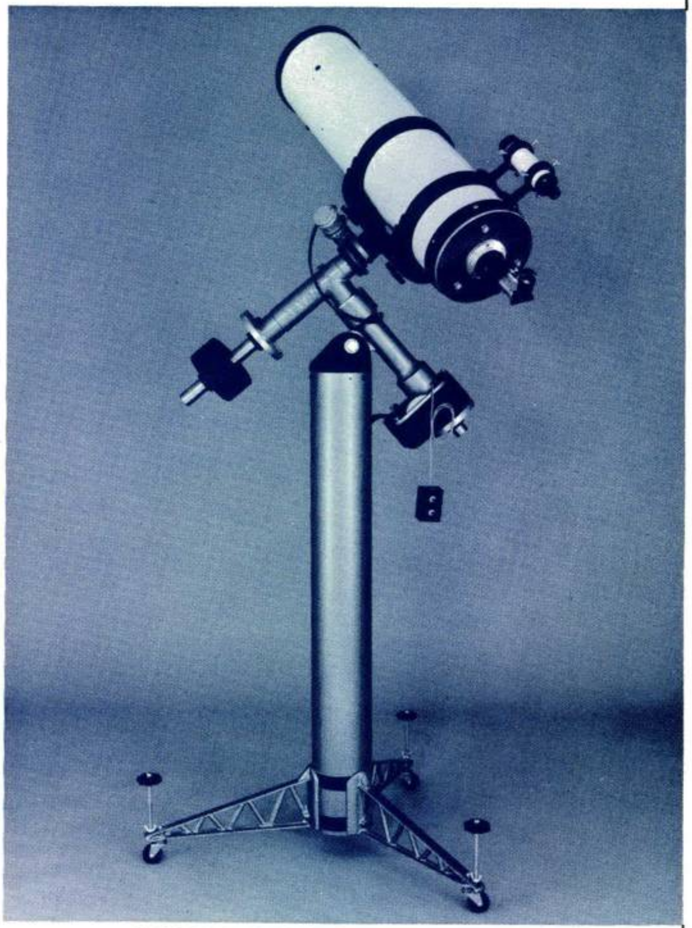

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ASTRONOMY

The World's Most Beautiful Astronomy Magazine

July 1974 Vol. 2, No. 7

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Typesetting by Grafilm, Inc.,
Milwaukee, Wisconsin 53208.

Separations prepared by
American Color Systems,
New Berlin, Wisconsin 53151

Printed by W. A. Krueger Co.,
Brookfield, Wisconsin 53005.

4 **ASTRONOMY FROM SKYLAB**
by Robert A. Parker

SKY ALMANAC

19 **Moon Hides Venus in Celestial Cover-up**

25 **ASTRO-NEWS**

GUEST OPINION

27 **Night Thoughts — Kenya, Jan. 28, 1974**
by Ian McLennan

STELLAR FRONTIERS

32 **What Radio Eyes Would See**
by Gerrit L. Verschuur

38 **PUBLISHER'S MEMO**

PHOTOGRAPHY IN ASTRONOMY

42 **Some Elements of Astrophotography**
by Jack Newton

49 **ASTRO-MART**

53 **ASTRONOMY REVIEWS**

GAZER'S GAZETTE

56 **Observing the Crescent Moon**

EQUIPMENT ATLAS

60 **An Introduction to Small Telescopes**
by Alan E. Nourse

68 **IN FOCUS**

70 **JULY STAR DOME**

CONSTELLATION CLOSE-UP

74 **Sagittarius**
by Thomas C. Bretl

Cover Photo

American Science and Engineering Photograph

This X-ray photograph of the sun was taken from a rocket shortly after the eclipse of March 7, 1970. X-rays are emitted by coronal plasmas which have temperatures of millions of degrees and are shaped by the solar magnetic fields. This photograph shows the structure of the general corona and the complexity of the magnetic interconnections both within and between the various centers of activity. Similar photos (see page 12) were taken regularly from Skylab.

Published monthly by AstroMedia Corp., 757 North Broadway, Suite 204, Milwaukee, Wisconsin 53202. Telephone (414) 276-2689.

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Second class postage paid at Milwaukee, Wisconsin.

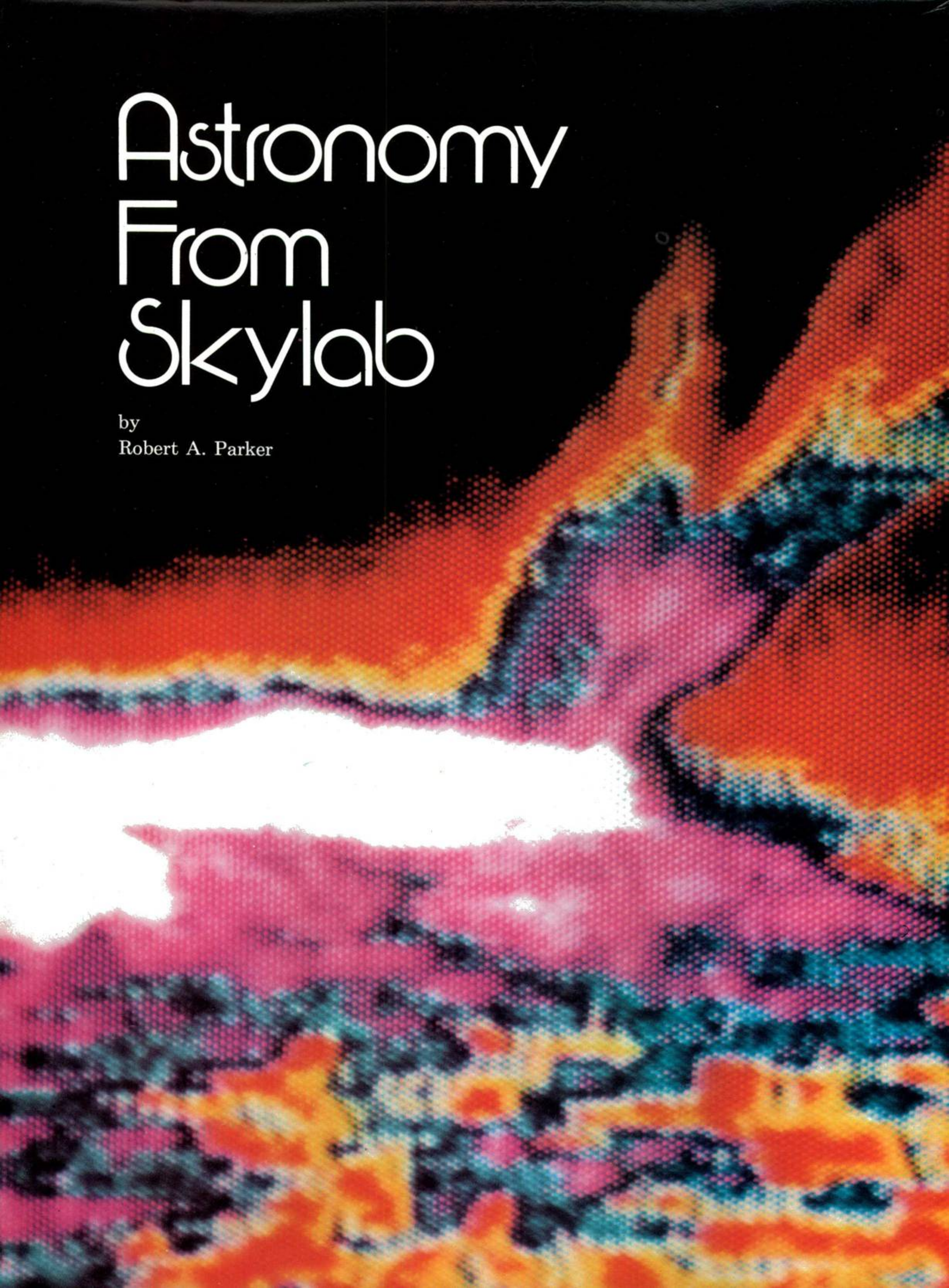
Direct all subscription correspondence, new subscriptions, changes of address and complaints to ASTRONOMY, Circulation Services, 640 North LaSalle Street, 6th Floor, Chicago, Illinois 60610. Allow six to eight weeks for address change to take effect.

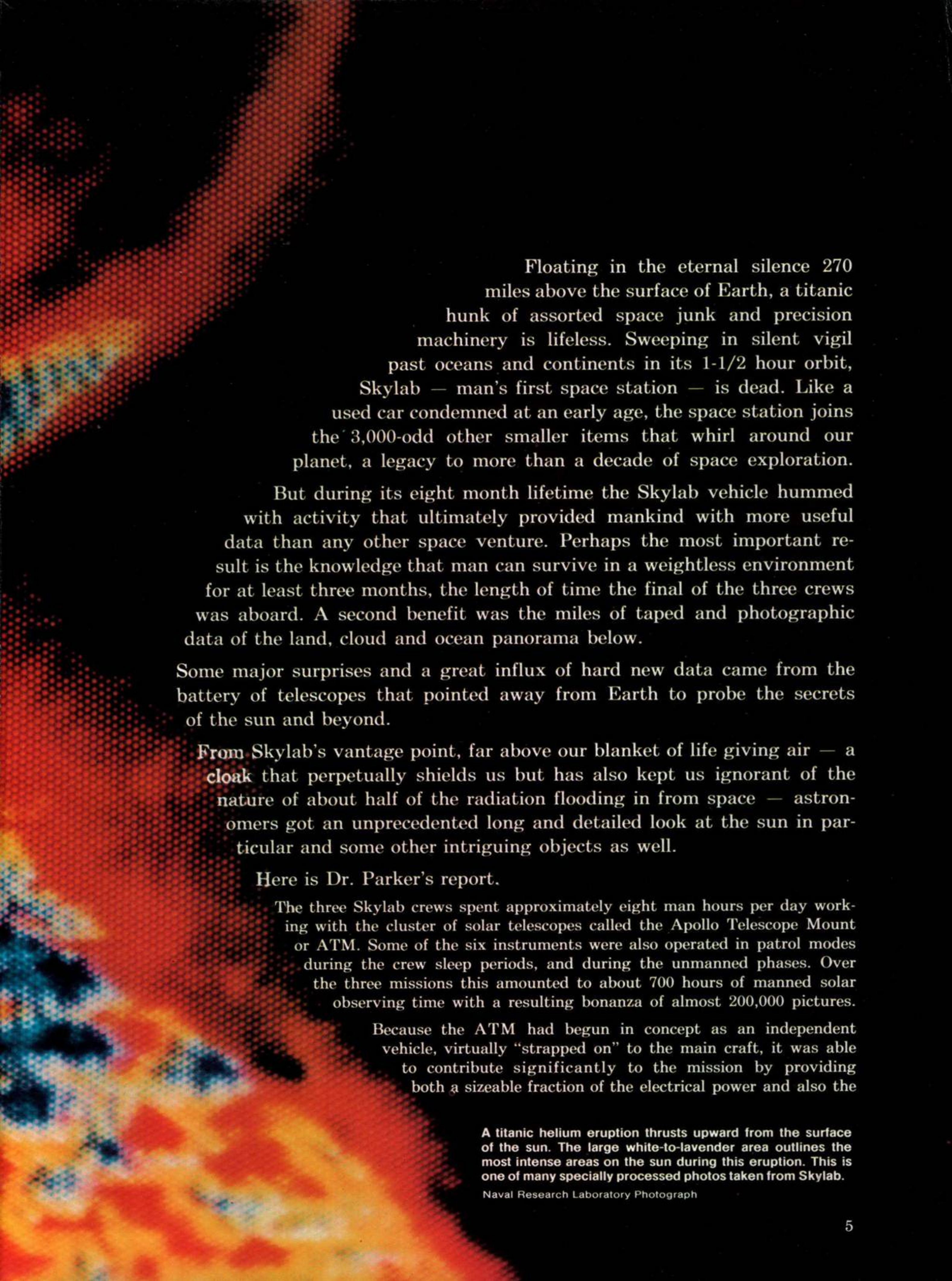
Cover price, $1.50. Subscription price: 1 year, $12.00; 2 years, $22.00; 3 years, $30.00. Canada and Mexico: add $3.00 per year. All other foreign: add $6.00 per year.

POSTMASTER: When undeliverable, send form 3579 to publisher.

Astronomy From Skylab

by
Robert A. Parker





Floating in the eternal silence 270 miles above the surface of Earth, a titanic hunk of assorted space junk and precision machinery is lifeless. Sweeping in silent vigil past oceans and continents in its 1-1/2 hour orbit, Skylab — man's first space station — is dead. Like a used car condemned at an early age, the space station joins the 3,000-odd other smaller items that whirl around our planet, a legacy to more than a decade of space exploration.

But during its eight month lifetime the Skylab vehicle hummed with activity that ultimately provided mankind with more useful data than any other space venture. Perhaps the most important result is the knowledge that man can survive in a weightless environment for at least three months, the length of time the final of the three crews was aboard. A second benefit was the miles of taped and photographic data of the land, cloud and ocean panorama below.

Some major surprises and a great influx of hard new data came from the battery of telescopes that pointed away from Earth to probe the secrets of the sun and beyond.

From Skylab's vantage point, far above our blanket of life giving air — a cloak that perpetually shields us but has also kept us ignorant of the nature of about half of the radiation flooding in from space — astronomers got an unprecedented long and detailed look at the sun in particular and some other intriguing objects as well.

Here is Dr. Parker's report.

The three Skylab crews spent approximately eight man hours per day working with the cluster of solar telescopes called the Apollo Telescope Mount or ATM. Some of the six instruments were also operated in patrol modes during the crew sleep periods, and during the unmanned phases. Over the three missions this amounted to about 700 hours of manned solar observing time with a resulting bonanza of almost 200,000 pictures.

Because the ATM had begun in concept as an independent vehicle, virtually "strapped on" to the main craft, it was able to contribute significantly to the mission by providing both a sizeable fraction of the electrical power and also the

A titanic helium eruption thrusts upward from the surface of the sun. The large white-to-lavender area outlines the most intense areas on the sun during this eruption. This is one of many specially processed photos taken from Skylab.

Naval Research Laboratory Photograph

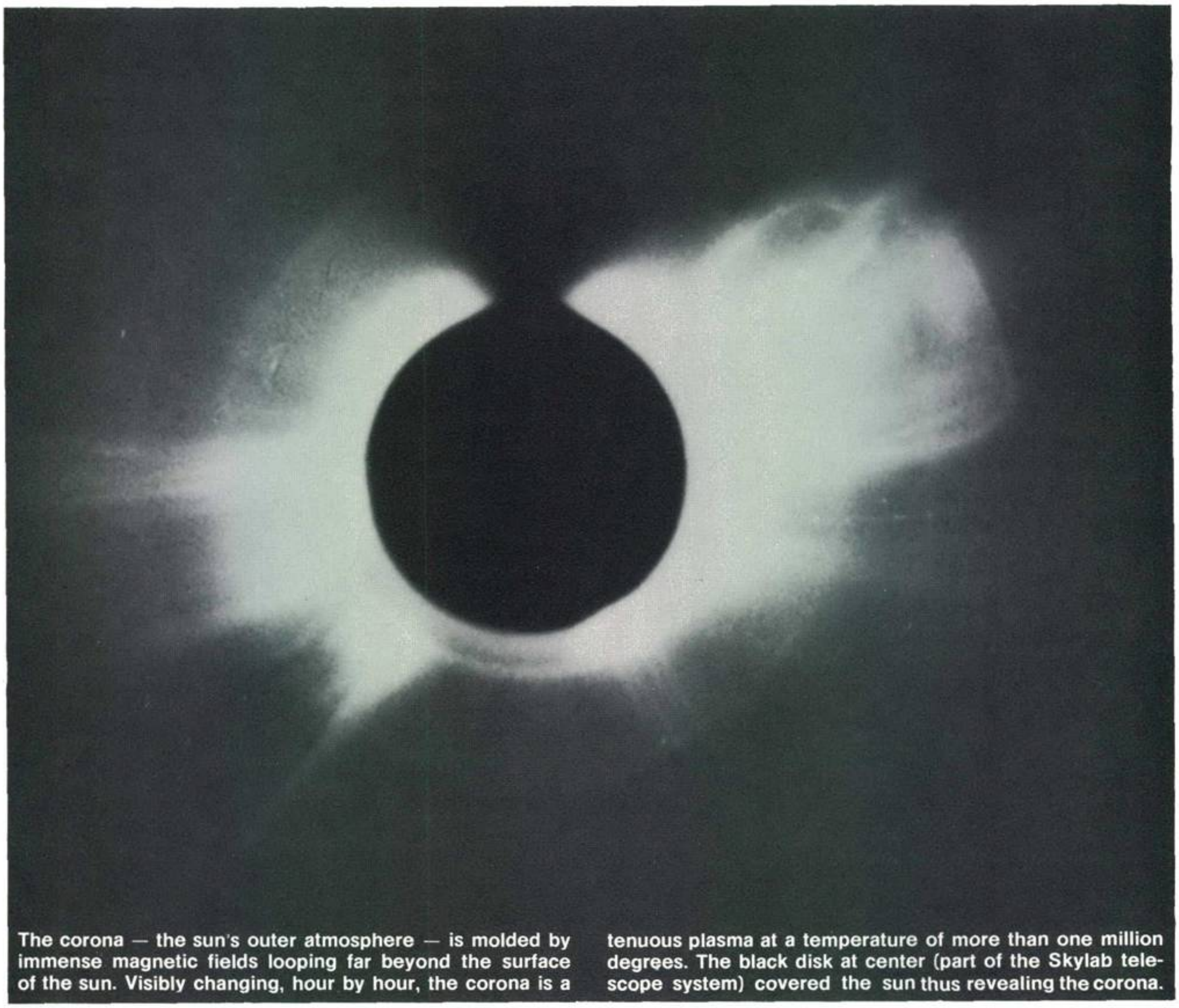
attitude control gyros that stabilized the entire Skylab vehicle. When the meteor shield on the Workshop was ripped off during launch — carrying one solar array with it and leaving the other one restrained against the side of the vehicle — it was power from the ATM solar panels that kept the Skylab vehicle alive for the first 25 days of the mission until the crew was able to free the remaining solar wing during a dramatic spacewalk.

The solar telescopes on Skylab were descendants of instruments that had earlier flown on Orbiting Solar Observatories (OSO) and other unmanned satellites. But Skylab was much larger than unmanned spacecraft, so more and better instrumentation was on board. Another prime advantage was the presence of highly skilled astronauts who zeroed in on targets of interest at a moment's notice.

One of the solar instruments was a coronagraph, a telescope with a special occulting device that blocks the main disk of the sun so that its atmosphere (the corona) becomes visible. Because they still have to contend with a bright sunlit sky, ground based observatory coronagraphs are only able to work effectively out to approximately 1.5 solar radii. The Skylab coronagraph looked at the fainter outer corona from 1.5 to 6 solar radii (see photos, pages 6 and 7). This region is normally accessible only during total solar eclipses. Therefore the several hundred hours of coronagraph observations spanning eight months, that were brought back by the Skylab crews, can be compared with a few minutes of observations obtained each year on the ground during eclipses.

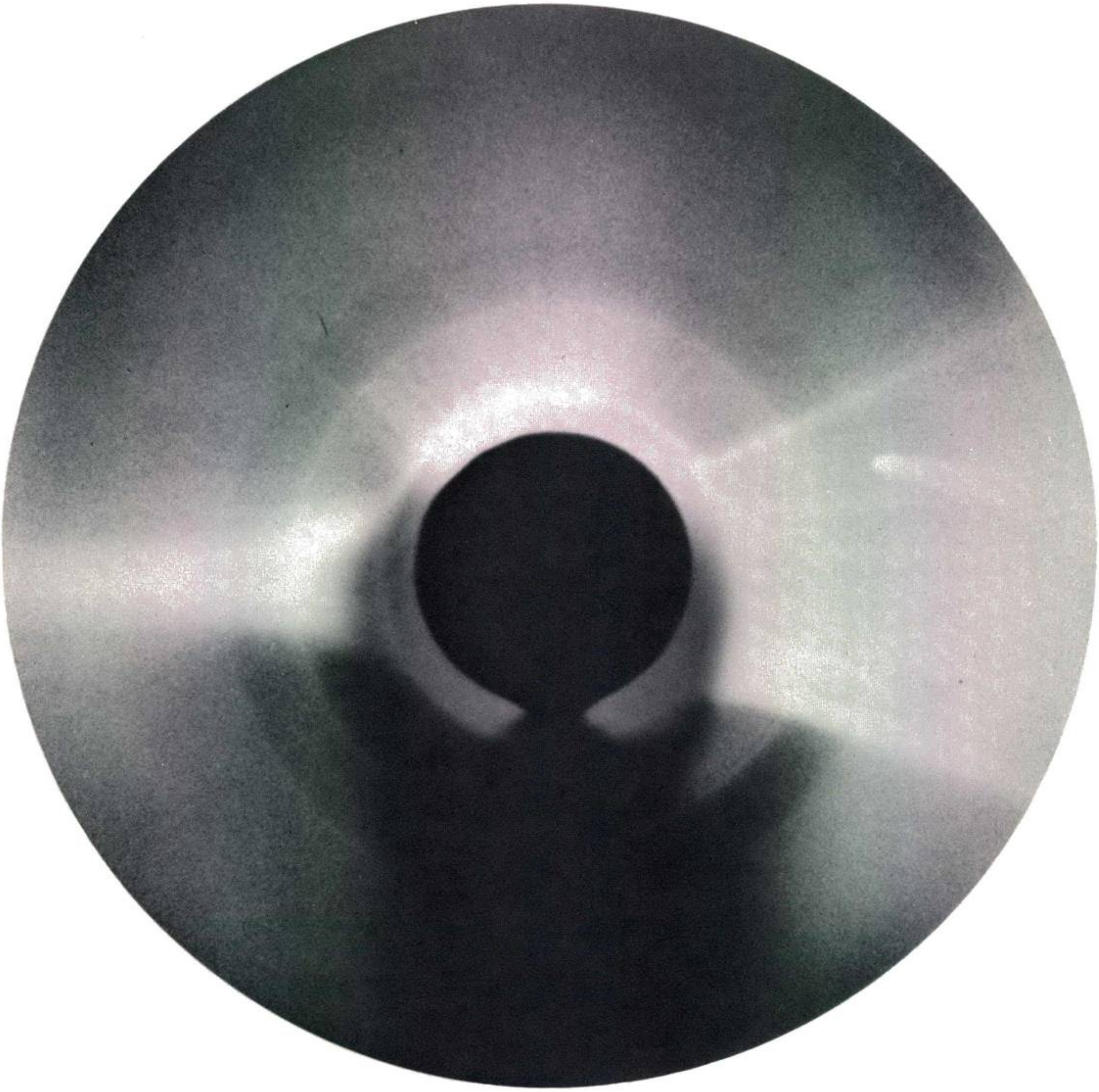
Before the launch of Skylab, one of the most important questions about the solar corona concerned the time scale of changes within it. From one total eclipse to the next the corona was observed to change, but it was not clear whether other changes took place more rapidly. Were there changes within weeks or days or hours?

Now with Skylab's sequence of closely spaced photographs covering more than eight full solar rotations, it is clear that the corona is a dynamic portion of the sun with changes occurring within hours. Among the features observed were "coronal



The corona — the sun's outer atmosphere — is molded by immense magnetic fields looping far beyond the surface of the sun. Visibly changing, hour by hour, the corona is a tenuous plasma at a temperature of more than one million degrees. The black disk at center (part of the Skylab telescope system) covered the sun thus revealing the corona.

High Altitude Observatory Photograph



High Altitude Observatory Photograph

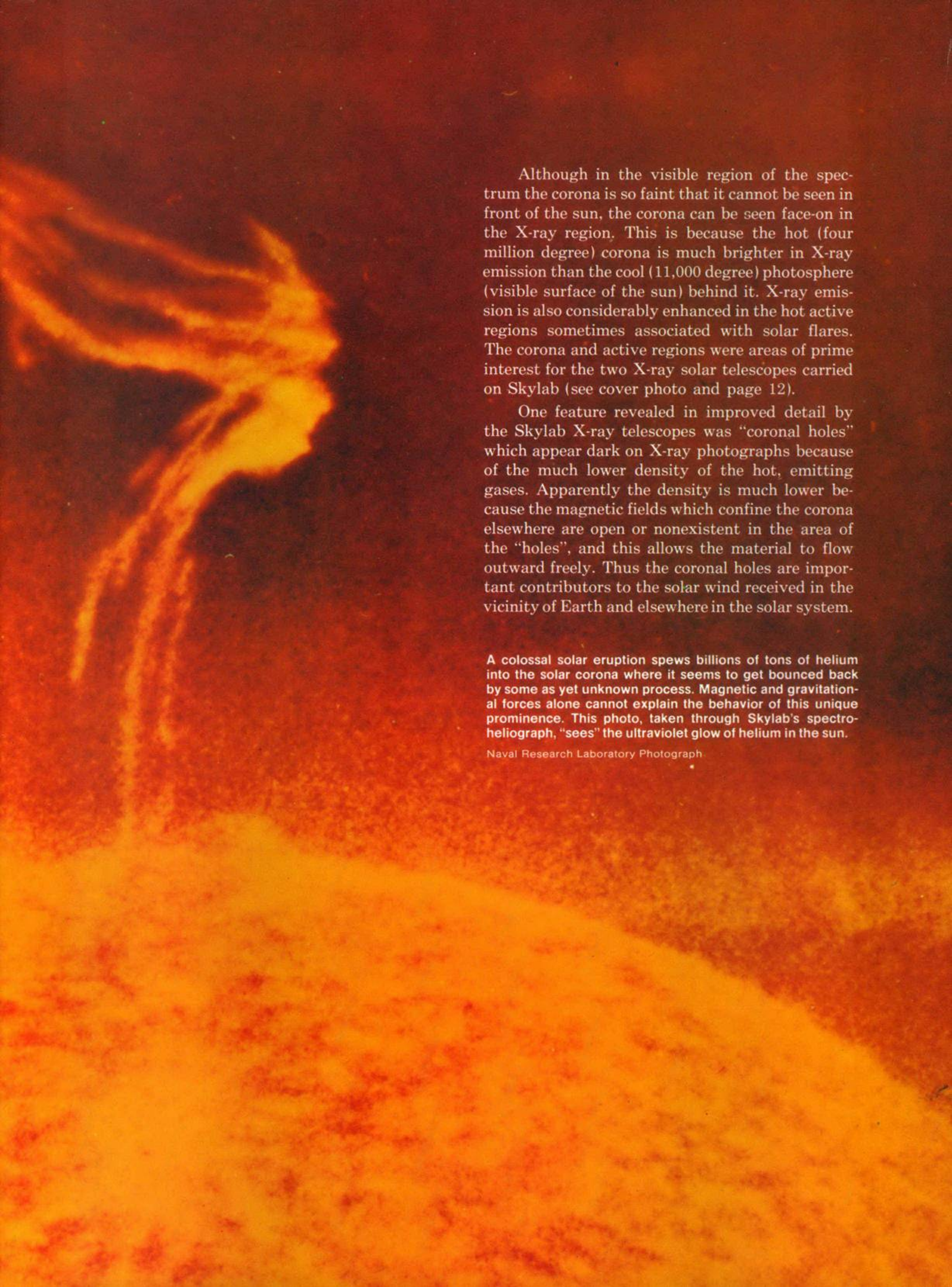
Comet Kohoutek seems immersed in the solar corona to the right of the black disk that blocks the sun's dazzling face in this Skylab photo taken Dec. 27, 1973. Actually the comet was 14 million miles beyond the sun at this time (28 hours prior to its closest approach of 13 million miles).

transients" during which (as a result of eruptive prominences and other activity in the lower layers of the sun) great "bubbles" of material, surging outward at one million m.p.h., grew to volumes the size of the whole sun over a period of several hours, greatly distorting the coronal magnetic field. (A photograph taken from Skylab of a coronal transient was previously published in ASTRONOMY on page 49 in the Feb. 1974 issue.) By watching the slower changes in the corona as the sun rotated, it will be possible to get a meaningful three-dimensional model of the sun's outer atmosphere.

A coronagraph was flown on OSO 7 — but its best resolution of 60 seconds of arc was considerably poorer than the eight second resolution of the Skylab coronagraph. The improved results from the Skylab coronagraph are typical of those realized from all the Skylab solar telescopes.

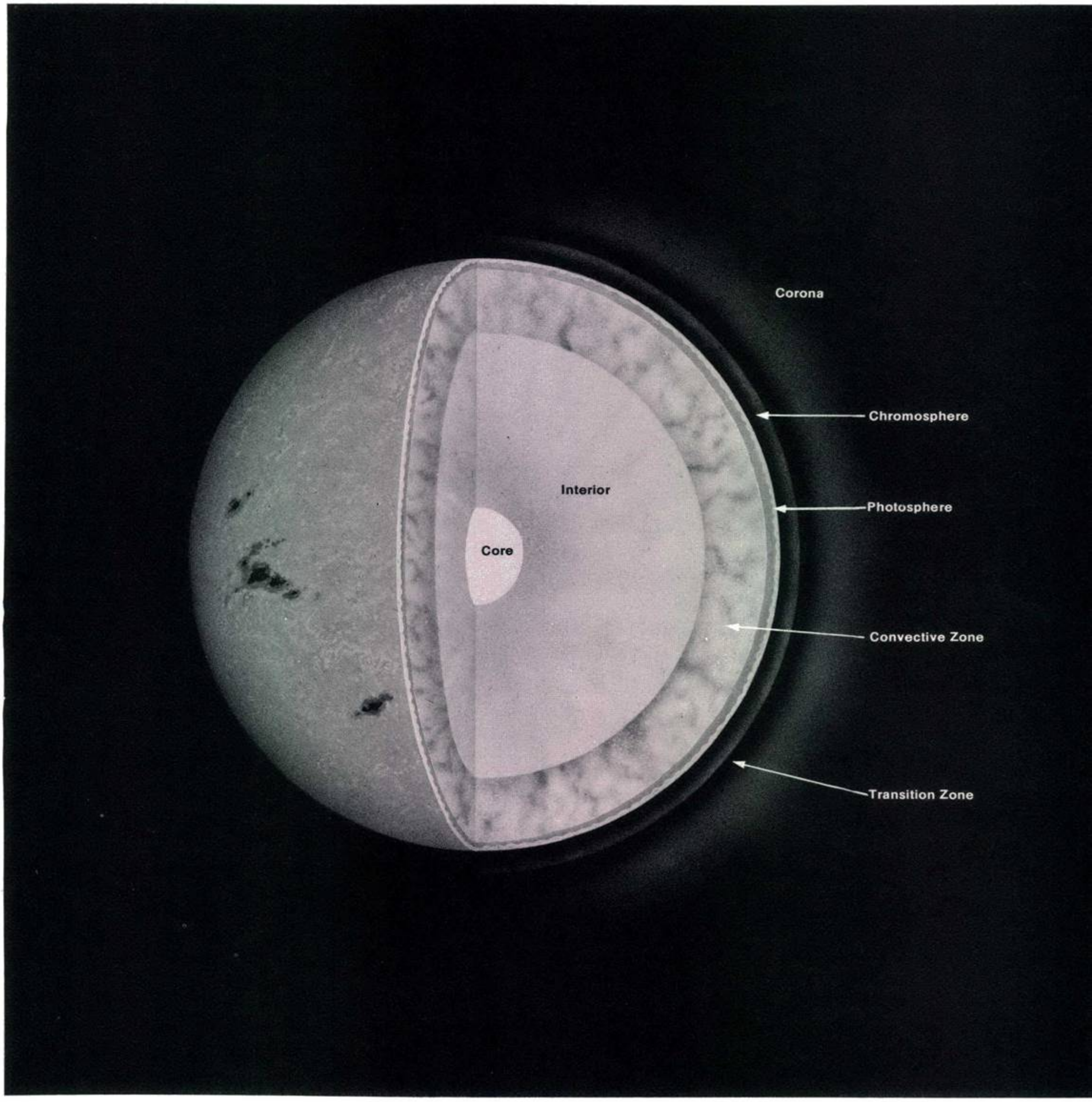
Although in the visible region of the spectrum the corona is so faint that it cannot be seen in front of the sun, the corona can be seen face-on in the X-ray region. This is because the hot (four million degree) corona is much brighter in X-ray emission than the cool (11,000 degree) photosphere (visible surface of the sun) behind it. X-ray emission is also considerably enhanced in the hot active regions sometimes associated with solar flares. The corona and active regions were areas of prime interest for the two X-ray solar telescopes carried on Skylab (see cover photo and page 12).

One feature revealed in improved detail by the Skylab X-ray telescopes was "coronal holes" which appear dark on X-ray photographs because of the much lower density of the hot, emitting gases. Apparently the density is much lower because the magnetic fields which confine the corona elsewhere are open or nonexistent in the area of the "holes", and this allows the material to flow outward freely. Thus the coronal holes are important contributors to the solar wind received in the vicinity of Earth and elsewhere in the solar system.



A colossal solar eruption spews billions of tons of helium into the solar corona where it seems to get bounced back by some as yet unknown process. Magnetic and gravitational forces alone cannot explain the behavior of this unique prominence. This photo, taken through Skylab's spectroheliograph, "sees" the ultraviolet glow of helium in the sun.

Naval Research Laboratory Photograph



The structure of the corona as seen on the face of the sun in the X-ray region matches well with the corona seen in visible light at the edge of the sun. Magnetic lines of force mold the intricate structure of the entire corona.

A nagging question has long been asked by solar astronomers: How is the corona heated to a temperature of a few million degrees by a photosphere of 11,000 degrees and a chromosphere of 40,000 degrees? It is generally believed that shock waves passing from the chromosphere to the corona are responsible for carrying the energy, but the exact model of how it is transferred is not understood.

Attempts to solve the problem have focused on the "transition region" where temperatures begin to rise above those in the chromosphere. Although the boundaries of this zone are not sharp we may roughly consider that the temperature increases from about 100,000 degrees at the bottom

INSIDE THE SUN

A rather ordinary, slightly larger-than-average star has been found to be a complex inferno of seething gases and lethal surges of radiation. Colossal ropes of gaseous helium and hydrogen loop above the rippling surface only to come plunging back, unable to escape the star's magnetic and gravitational grip.

What star is this? The sun of course — the only star we can examine at close range. And thanks to Skylab our picture of the sun, developed over the past century or so, has been vastly enlarged and focused.

With a diameter 109 times Earth's and a mass equal to 333,000 "Earths" or 1047 "Jupiters", the sun is a giant nuclear furnace where 655 million tons of hydrogen is fused into 650 million tons helium every second. The missing five million tons of matter is converted to energy in the process. All this action takes place at the sun's core at a temperature of 30 million degrees. The released energy actually takes thousands of years to work its way to the photosphere where it is radiated into space.

The photosphere is the visible surface of the sun where the temperature is a relatively cool 11,000 degrees. Here sunspots are born and, weeks or months later, decay in an unending, mysterious ritual. Titanic "flames" called prominences uproot billions of tons of solar photosphere in a perpetual demonstration of enormous magnetic and gravitation forces. The prominences swoop up into the next layer, the several thousand mile deep chromosphere. In this zone superheated gases are twirled by strong magnetic fields near sunspots. Eruptive events on the sun can spew matter at a million m.p.h. to heights of hundreds of thousands of miles.

Skylab studies helped define the nature of vast dome shaped bubbles of gas that accompany the eruption of highly intense blasts called flares. Do they contribute to the solar wind or does the matter plunge back? (The solar wind is the outer extensions of the corona, the sun's high temperatures, low density atmosphere.)

Why study the intricate details of our star? The answer should be obvious: It's our prime source of lifegiving energy. At present commercial rates the Earth receives $2,000,000 worth of solar energy every second. Knowledge of the sun is a down payment for the future.

Many areas of incomplete understanding still exist however, especially the relationship between solar differential rotation and convection. Due to the gaseous nature of the sun and the forces produced by its rotation, the equator of our star spins 20 percent faster than the poles — hence the term differential rotation. The convection zone must be deeply affected by this internal twisting. Just how it is, is a question near the top of the problem list of solar physicists.

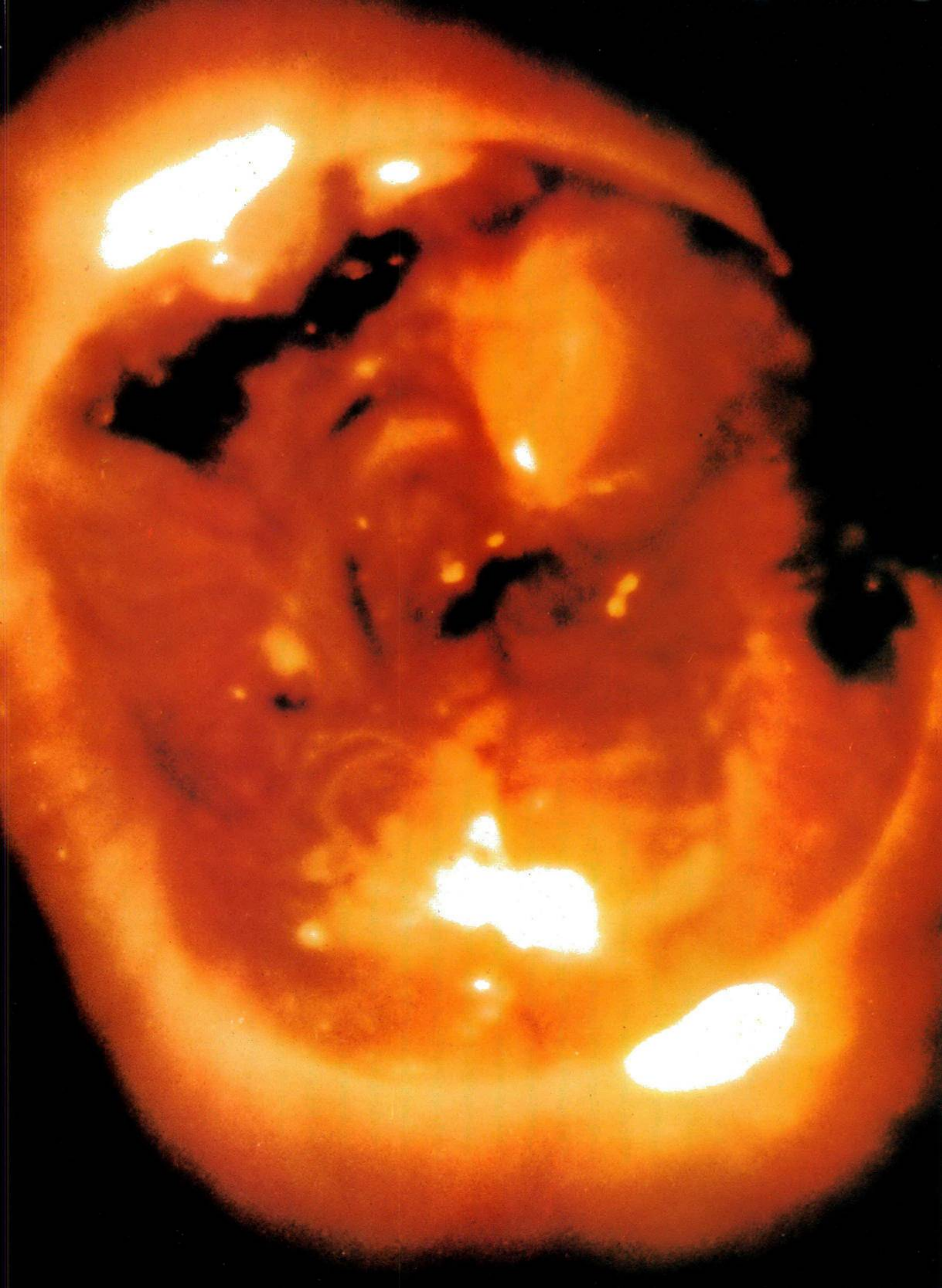
The exact source of sunspots is also an unknown. They are the centers of magnetic vortexes in the photosphere, but what is their origin and why do they vary in number following an 11 year cycle? For that matter, what drives the solar cycle in the first place?

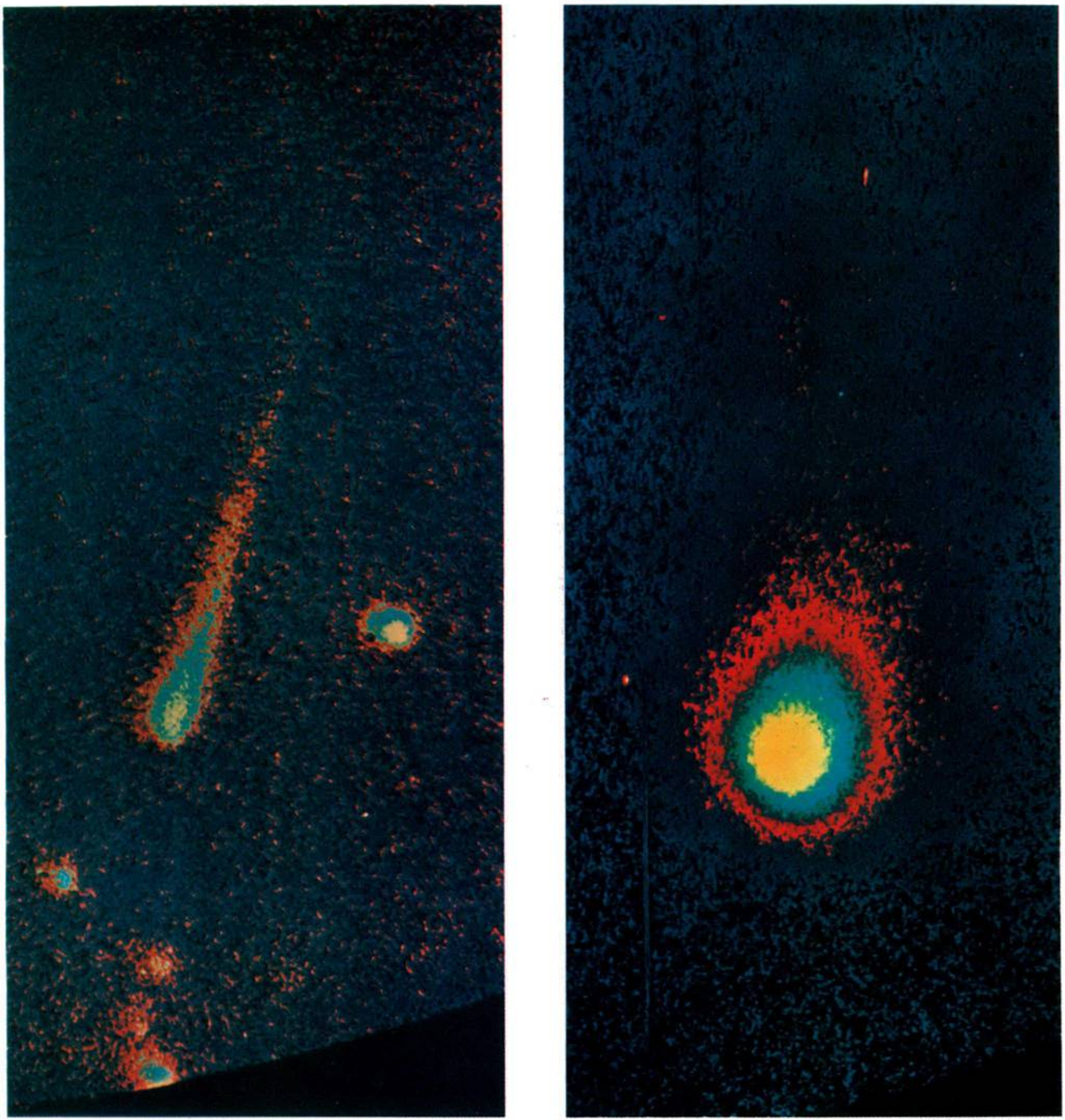
A further headache has been aggravated by recent results from an observatory a mile beneath the Black Hills of South Dakota. There, a 100,000 gallon tank of perchloroethylene acts as a chemical "telescope" that detects nutrinos from the sun. Nutrinos (a minor atomic particle) were predicted to be produced in the sun at levels 10 times higher than observed by the underground detector. Why? Is the sun's energy production at the core somehow variable?

And there are other unknowns, but our understanding of the structure of our star and the forces that drive it are far clearer than ever before.

to about 2,000,000 degrees at the top of the transition region. In this range of temperatures we find many ions whose important spectral lines lie in the extreme ultraviolet, or XUV. A given species of ion exists over a fairly narrow temperature range, so a picture taken at the wavelength emitted by a particular ion is, in effect, a picture of a definite layer of the sun or its atmosphere. Pictures in the XUV were obtained by two spectroheliographs carried on Skylab (pages 8 and 16).

The plan of attack used on Skylab was to get simultaneous observations in a number of wavelengths, and with several instruments (thus, for example, showing details of a number of layers in the transition region) so that a meaningful three-dimensional model can be developed. Closely spaced sequences of observations revealed how changes in one layer move on to affect other layers. The whole picture will soon be further tied together because observations were made from





NASA Photographs

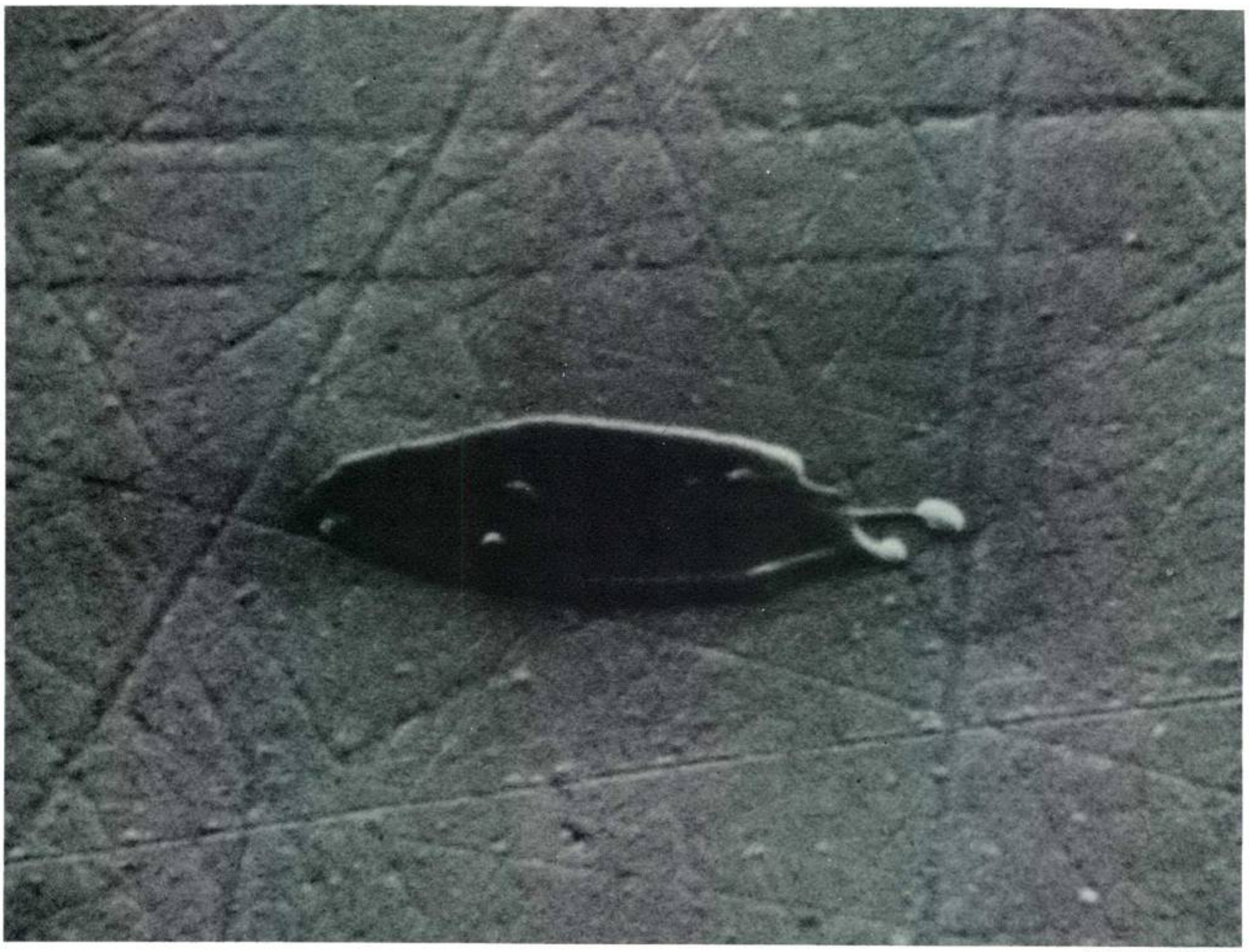
Two views of Comet Kohoutek were photographed by astronaut William R. Pogue during a "space walk" outside Skylab on Christmas Day 1973. An original 95 second exposure on far ultraviolet film has been processed (left) to show increasing brightness by steps. From faintest to brightest the colors are arranged: blue, red, green, yellow. The brightness of the comet's head and tail is probably due to ultraviolet radiation from the sun reflected off dust particles. Some stars are detected in this photo — the brightest (to the right of the comet) is 63 Ophiuchi, a sixth magnitude star to human eyes but about first magnitude in far ultraviolet because most of its radiation is in that wavelength. Comet Kohoutek's 1.6 million mile diameter hydrogen halo is clearly shown (right) in another false color print of a far ultraviolet photo that uses the same color scheme as the previous picture. This 2-1/2 second exposure was filtered to center on a wavelength that precisely detects the activity of hydrogen.

Earth's surface at the same time that the Skylab experiments were operating.

This X-ray photo of the solar corona was taken from Skylab on May 28, 1973.

American Science and Engineering Photograph

Although the solar telescopes were located totally outside the vehicle and controlled electronically from a central console, other astronomy instruments were more like ordinary telescopes. A small (9" x 9") hole called a scientific airlock — in the side of Skylab — replaced the slit on the



NASA Photograph

This is a highly magnified view of a smooth piece of metal that was left outside Skylab for several weeks. The very fine scratch marks are the result of polishing the surface prior to the mission but the "splash" is the scar of a micrometeorite impact. The object which melted and splashed the material out of this shallow crater may have left some of itself in the melted material. Analysis now underway may reveal the chemical composition of micrometeorites.

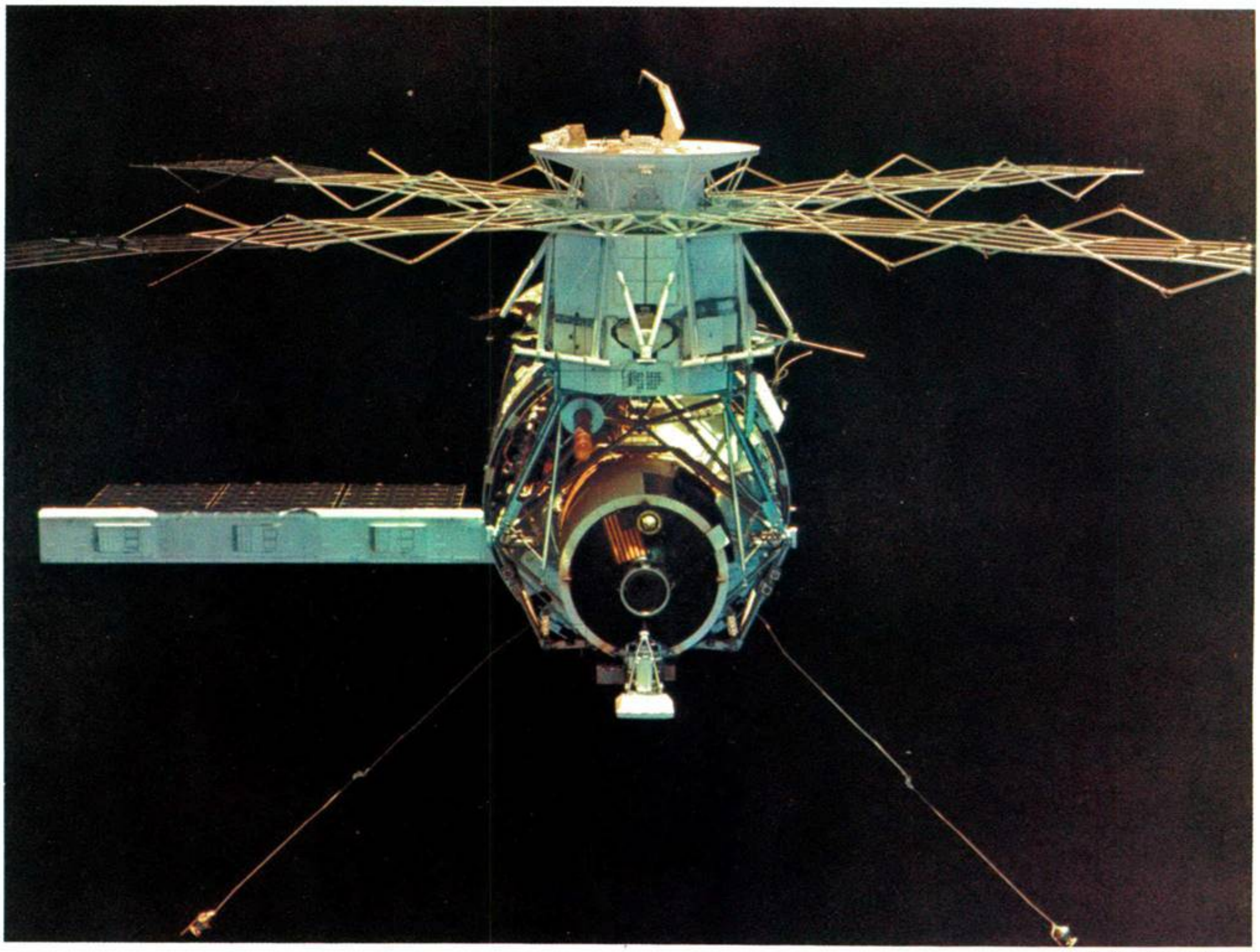
usual observatory dome. The telescopes could also make use of an articulated mirror system which could be extended through the scientific airlock. This allowed the instrument, which was inside and fixed to the side of the vehicle, to look at many objects by merely moving the mirror without having to maneuver the Skylab. Originally there were two scientific airlocks — one for the sunside and one for the antisunside — but following the loss of the meteor shield, the one on the sunside was used for deployment of the "parasol" solar shield and so was not available for the solar experiments that had originally planned to use it.

One of the most successful of the astronomy experiments that used the dark side airlock was an objective prism instrument utilized for a far ultraviolet spectral survey of portions of the Milky Way. Spectra were obtained for hot blue stars (class BO) down to magnitude 6.6. With catalogs derived from data such as this, selections can be made in the future for objects to be studied in greater detail by more "high powered" telescopes to be flown on the Space Shuttle missions or later on in the 1980s by the Large Space Telescope (120 inch) scheduled to be placed in orbit by the Shuttle.

With the discovery of Comet Kohoutek last spring a great deal of effort was expended to organize an observing program to take advantage of the unique opportunities that the Skylab missions might provide. In fact, one new instrument, an electrographic camera, was prepared and carried up on the last mission expressly to observe Kohoutek. Even though Kohoutek did not turn out to be as spectacular as some people had predicted,

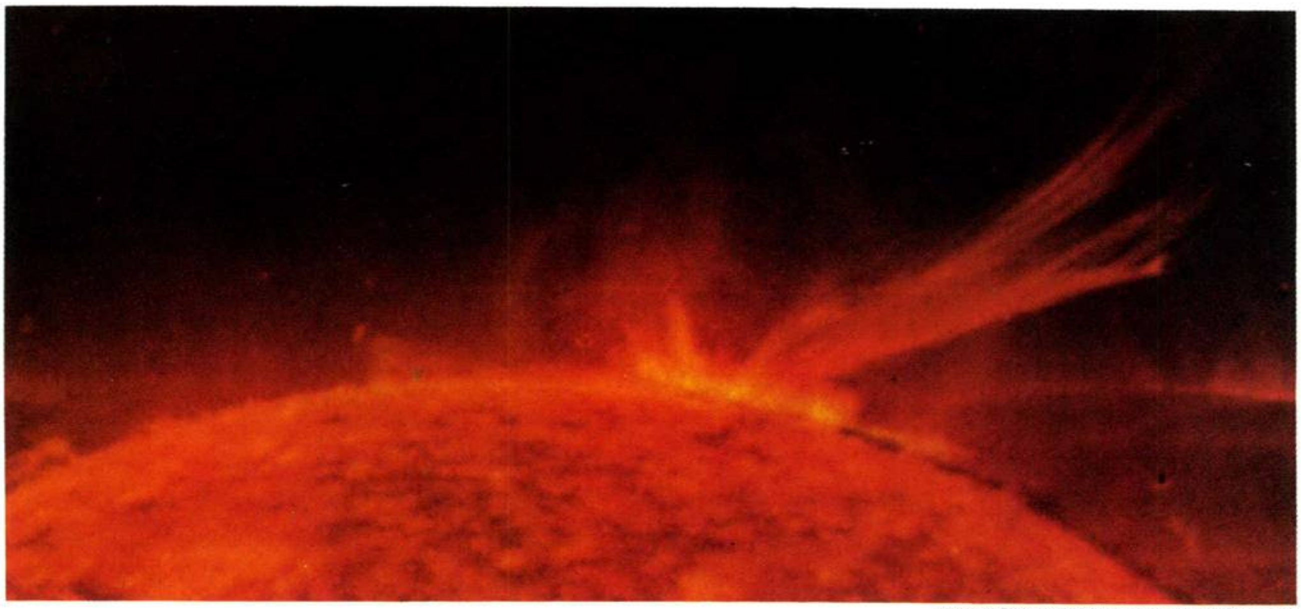
From the surface of Earth the sun seems tranquil compared to some of the Skylab views. Until the advent of space observatories our knowledge of the dynamic nature of the sun was limited by the obscuring effect of our atmosphere. This view actually corresponds to what the eye sees through a properly filtered Earthbound telescope. Currently there are fewer sunspots dotting our star than when this photo was taken in 1957.

Hale Observatories Photograph



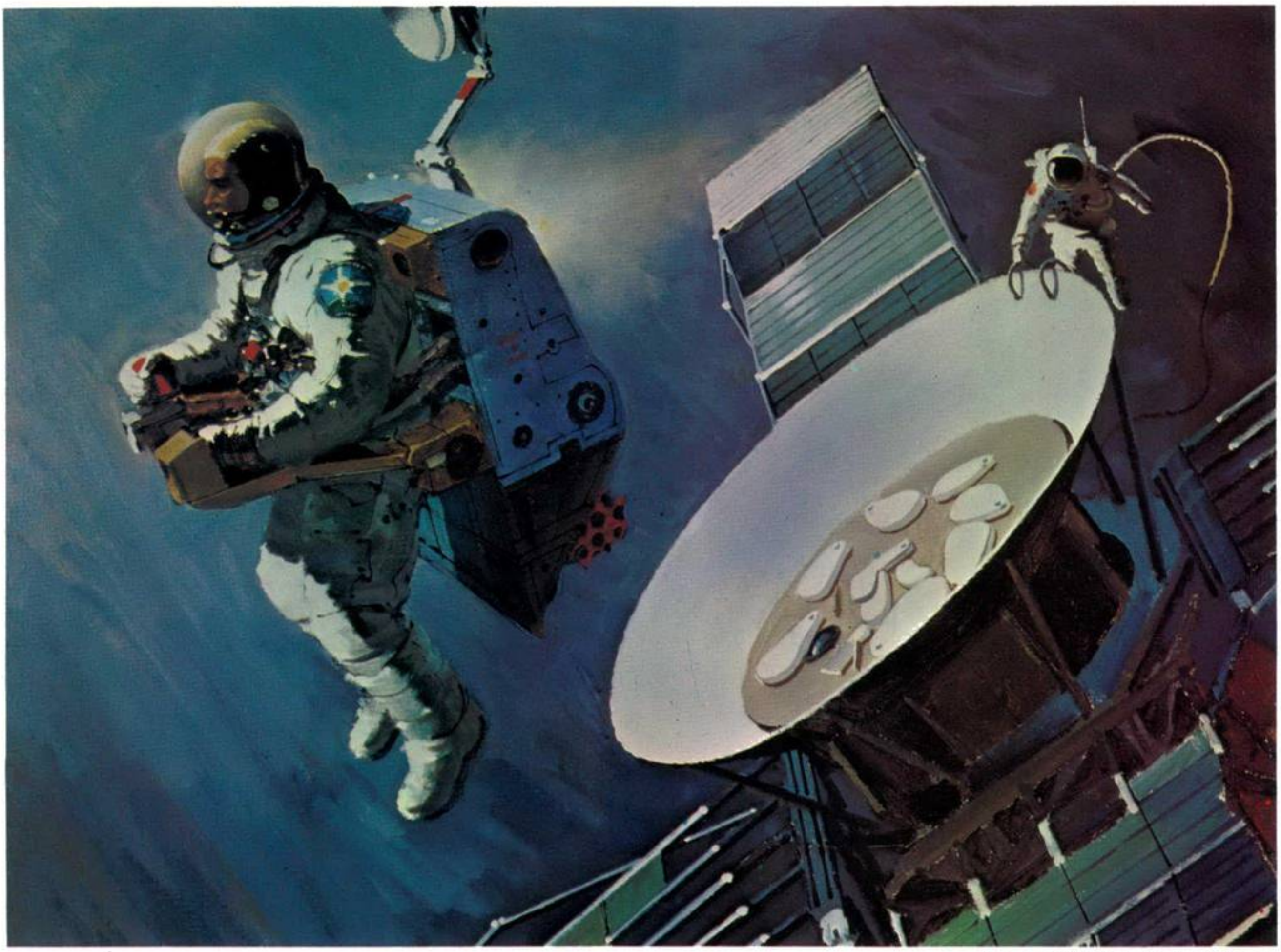
NASA Photograph

Skylab, as seen by the last crew just after their departure on Feb. 8, 1974. The docking adapter is the circular device just below center. Above it is the Apollo Telescope Mount housing the solar telescopes and supporting four winglike solar arrays. To the left is a single solar wing, seen more clearly on page 40.



Naval Research Laboratory Photograph

Another helium eruption was captured by one of Skylab's spectroheliographs. The cell structure seen on the sun is part of the mysterious region between the solar surface and the corona called the transition region.



Artwork©1974 by Robert McCall

Skylab crewman testing an astronaut maneuvering unit. (The unit was tested inside Skylab, although it is intended for exterior use; courtesy of artist's license, it is shown that way here.) At right is the ApolloTelescope Mount surrounded by the four solar wings that were the principal source of solar power for Skylab before the crippled panel was deployed. (From *Our World in Space*, published by the New York Graphic Society.)

the opportunities to get so much data on the comet in the UV and to observe it so intensely with the ATM solar telescopes during its close approach to the sun provided significant amounts of new information.

Perhaps the most unusual astronomical instrument used on Skylab consisted of several pieces of carefully polished metal that were attached outside the space station for four to six weeks. They were then examined back on Earth for tiny pits caused by micrometeorites (smaller than dust size meteors). Initial results from this experiment indicate that the micrometeorite density, in Skylab's zone of space, is at the low end of the wide range previously measured (photo, page 14).

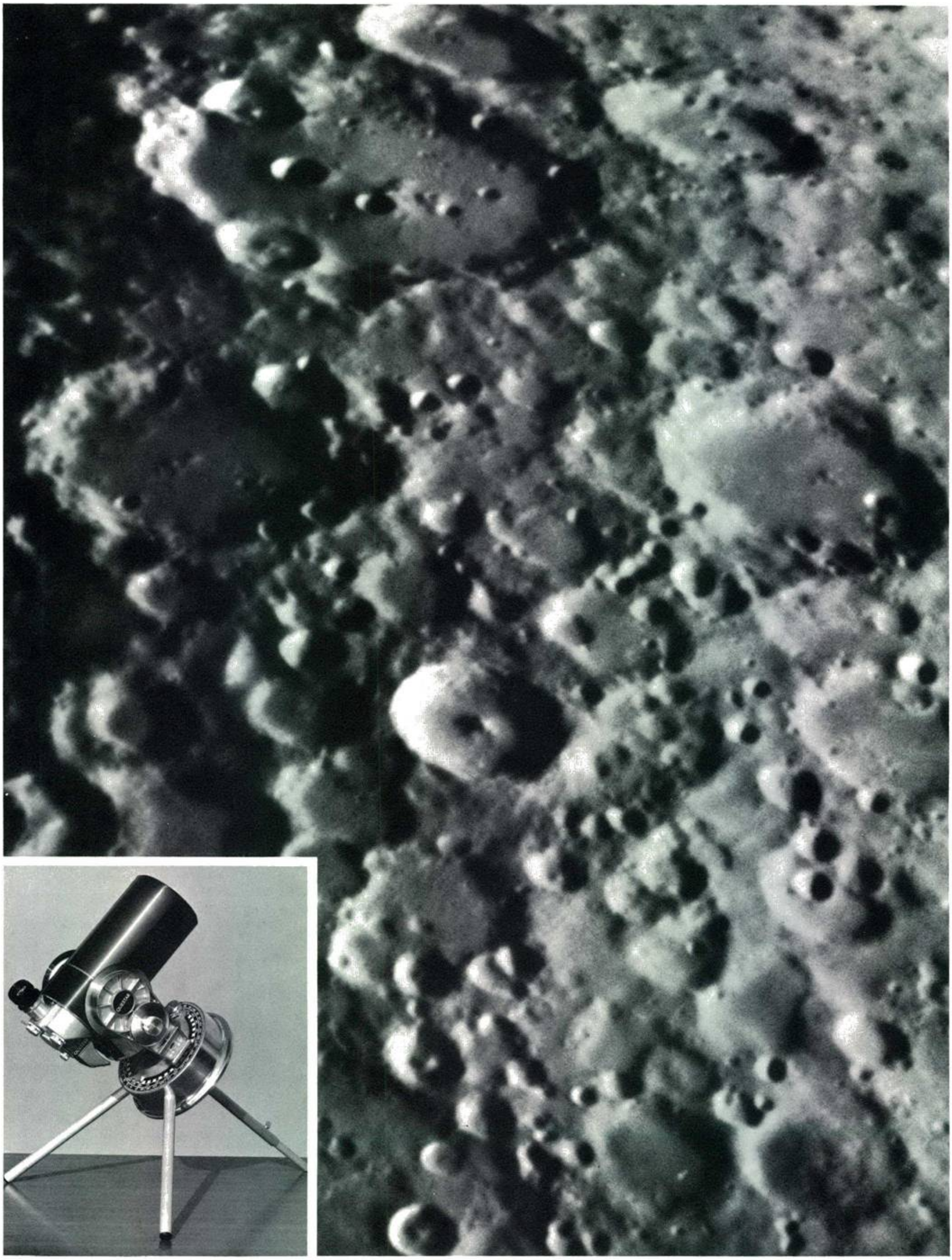
The legacy of Skylab is still being evaluated and it will be years before all the results are in. But in future accounts of man's efforts to understand his place in the cosmic environment, Skylab will stand as a significant step forward.

Dr. Robert Parker is one of NASA's scientist/astronauts. During the Skylab mission he served as Skylab Program Scientist, responsible for accommodating all the science requirements into a workable plan. Before that he had worked on the support crews of Apollo 15 and Apollo 17. When he was selected for the astronaut program in 1967 he was an associate professor of astronomy at the University of Wisconsin.

Centerfold

NASA Photograph

The Skylab workshop was photographed by the final crew after they had undocked and were getting ready to come home. The missing solar wing was lost during launch. The gold colored "twinpole sunshield" was put in place by the second of the three crews. Two corners of the first crew's "parasol sunshield" (darker gold) are visible peeking out from under the twinpole sunshield. Also easily visible is the sunward end of the Apollo Telescope Mount (ATM) which houses the group of solar telescopes and is surrounded by a "windmill" of solar panels. During seven film exchange EVAs the Skylab crew members climbed out to the side and sun end of the ATM cannister to retrieve and replace five loads of film.



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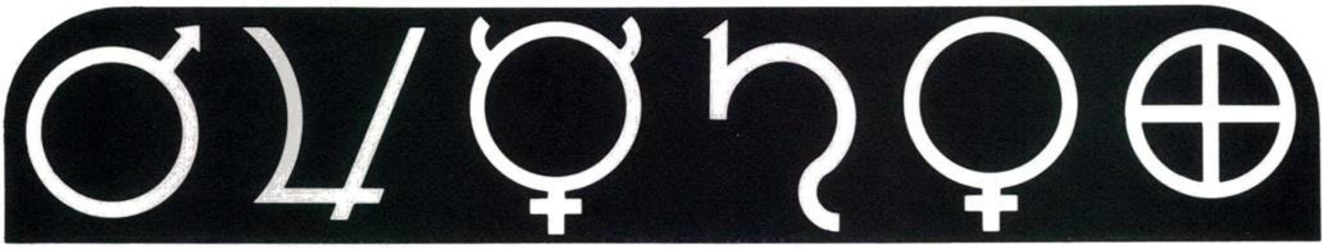


SKY ALMANAC

Moon Hides Venus in Celestial Cover-up

With no planets conveniently placed for evening viewing it would be a dull month were it not for the rare passage of the moon directly in front of Venus.

Occultation of Venus

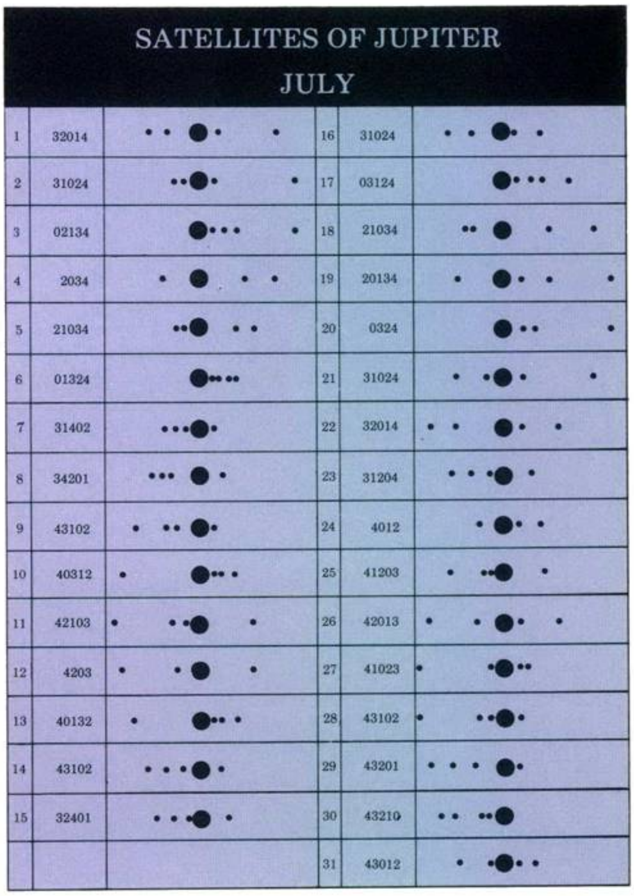
In the world of celestial happenings an eclipse of the sun is an infrequent event. An eclipse of a bright planet by the moon (called an occultation) is even more uncommon. This time it involves the brightest of all planets, Venus — the next brightest object after the moon.

Early on the morning of July 17, low in the east, the thin crescent moon will seem to be hovering above brilliant Venus. Slowly the moon will sweep toward Venus and the planet will seem to touch the edge of our satellite. At first the planet will slowly, almost imperceptibly, appear to be fading. Then it will rapidly be snuffed out — the decline taking about 20 seconds. Sometime later (depending on where you live) Venus will emerge as the moon moves by. The emergence will be even more spectacular since it occurs on the night side of the moon.

Everything described above can be seen with the unaided eye. But now for the bad news: You have to get up before 4 or 5 a.m. to see it. It will be worth it though. If you miss this one you will have to wait till May 14, 1977 for the next opportunity.

Now for more bad news: Anyone west of a line running from Michigan's upper peninsula through central Nebraska and down to San Antonio, Tex. will be out of luck. The moon will be either below the horizon or it will not occult Venus at all. The table gives further details.

In the table, note that the times are an approximate guide only. There may be variations of up to five minutes for your location. You should have no trouble watching Venus seem to

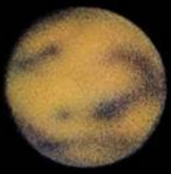


SATELLITES OF JUPITER

JULY

1	32014		16	31024	
2	31024		17	03124	
3	02134		18	21034	
4	2034		19	20134	
5	21034		20	0324	
6	01324		21	31024	
7	31402		22	32014	
8	34201		23	31204	
9	43102		24	4012	
10	40312		25	41203	
11	42103		26	42013	
12	4203		27	41023	
13	40132		28	43102	
14	43102		29	43201	
15	32401		30	43210	
			31	43012	

The four major satellites of Jupiter orbit the giant planet in periods ranging from just under 2 days to 17 days. They can be seen to change position from night to night. Sometimes their motions become evident after only a few minutes' observation. Only a small telescope is required to detect all four of the satellites and several can frequently be seen in rigidly held binoculars. This table shows the approximate positions of the moons at about midnight (EDT) on the evenings indicated. First column on the left shows the date. Second column of numbers identifies the moons and their positions relative to Jupiter's disk. (1 = Io; 2 = Europa; 3 = Ganymede; 4 = Callisto, and 0 = Jupiter's disk.) The third column approximates a telescopic view of the satellites' positions. The orientation of the satellites is shown inverted as seen in a standard astronomical telescope.



Ⓐ Mercury

July	1
R.A.	$6^{h}33^{m}$
Dec.	+18°39'
Dia.	11.8"
Mag.	+0.9

Ⓑ Mercury

July	15
R.A.	$6^{h}22^{m}$
Dec.	+19°35'
Dia.	9.2"
Mag.	-0.6

Ⓜ Mars

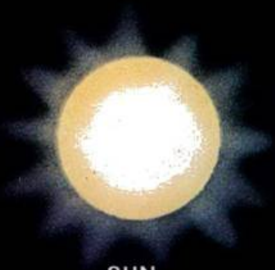
July	1	15
R.A.	$9^{h}08^{m}$	$9^{h}42^{m}$
Dec	+17°47'	+15°02'
Dia.	3.9"	3.8"
Mag.	+2.0	+2.0

Ⓒ Ceres

July	1	15
R.A.	$23^{h}23^{m}$	$23^{h}26^{m}$
Dec.	-17°02'	-17°58'
Mag.	+7.6	+7.4

Ⓝ Neptune

July	15
R.A.	$16^{h}22^{m}$
Dec.	-19°55'
Dia.	2.4"
Mag.	+ 7.7



SUN

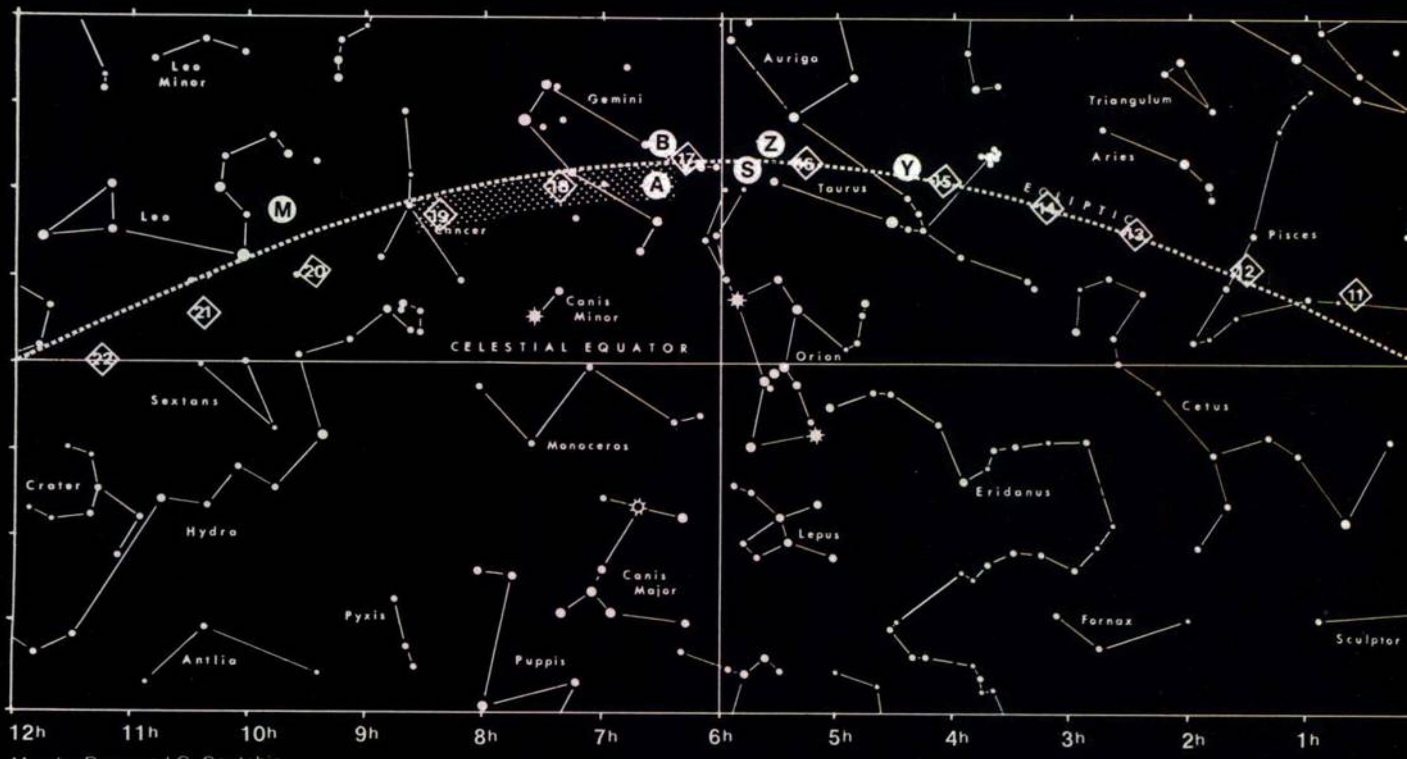
The sun is within the stippled zone throughout the month. Planets and stars near this area are not easily seen.

Ⓢ Saturn

July	1	15
R.A.	$6^{h}37^{m}$	$6^{h}45^{m}$
Dec.	+22°35'	+22°29'
Dia.	too near sun	
Mag.	too near sun	

Ⓤ Uranus

July	15
R.A.	$13^{h}29^{m}$
Dec.	-8°41'
Dia.	3.9"
Mag.	+ 5.8

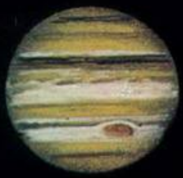

Leo Minor
Leo
Gemini
Aurigo
Triangulum
Aries
Taurus
Pisces
Cancer
Canis Minor
ECLIPTIC
CELESTIAL EQUATOR
Orion
Sextans
Monoceros
Cetus
Crater
Hydra
Eridanus
Lepus
Canis Major
Pyxis
Fornax
Sculptor
Antlia
Puppis
M
B
A
Z
S
Y
10
11
12
13
14
15
16
17
18
19
20
21
22
12h
11h
10h
9h
8h
7h
6h
5h
4h
3h
2h
1h

Map by Raymond G. Coutchie

The chart shows the positions of the moon, planets and brightest asteroids for the current month. Letters within the circles correspond to the letters beside each object in the data section above the map. Additional information about each object is given there. **R.A.** = right ascension and **Dec.** = declination, the two coordinates used to locate astronomical objects. The general coordinate system is indicated around the edge of the map. **Mag.** = magnitude, a

Ⓥ Vesta

July	1	15
R.A.	12h52m	13h08m
Dec.	+2°27'	-0°05'
Mag.	+6.6	+6.8



Ⓙ Jupiter

July	1	15
R.A.	23h17m	23h17m
Dec.	-5°56'	-6°01'
Dia.	38.9"	40.5"
Mag.	-1.9	-2.0

Ⓨ Venus

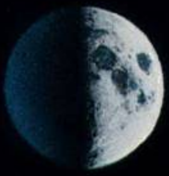
July	1
R.A.	4h22m
Dec.	+19°56'
Dia.	12.6"
Mag.	-4.1

Ⓩ Venus

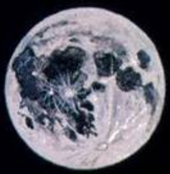
July	15
R.A.	5h33m
Dec.	+22°16'
Dia.	11.9"
Mag.	-4.2

Ⓟ Pluto

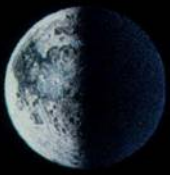
July	15
R.A.	12h41m
Dec.	+13°33'
Mag.	+14



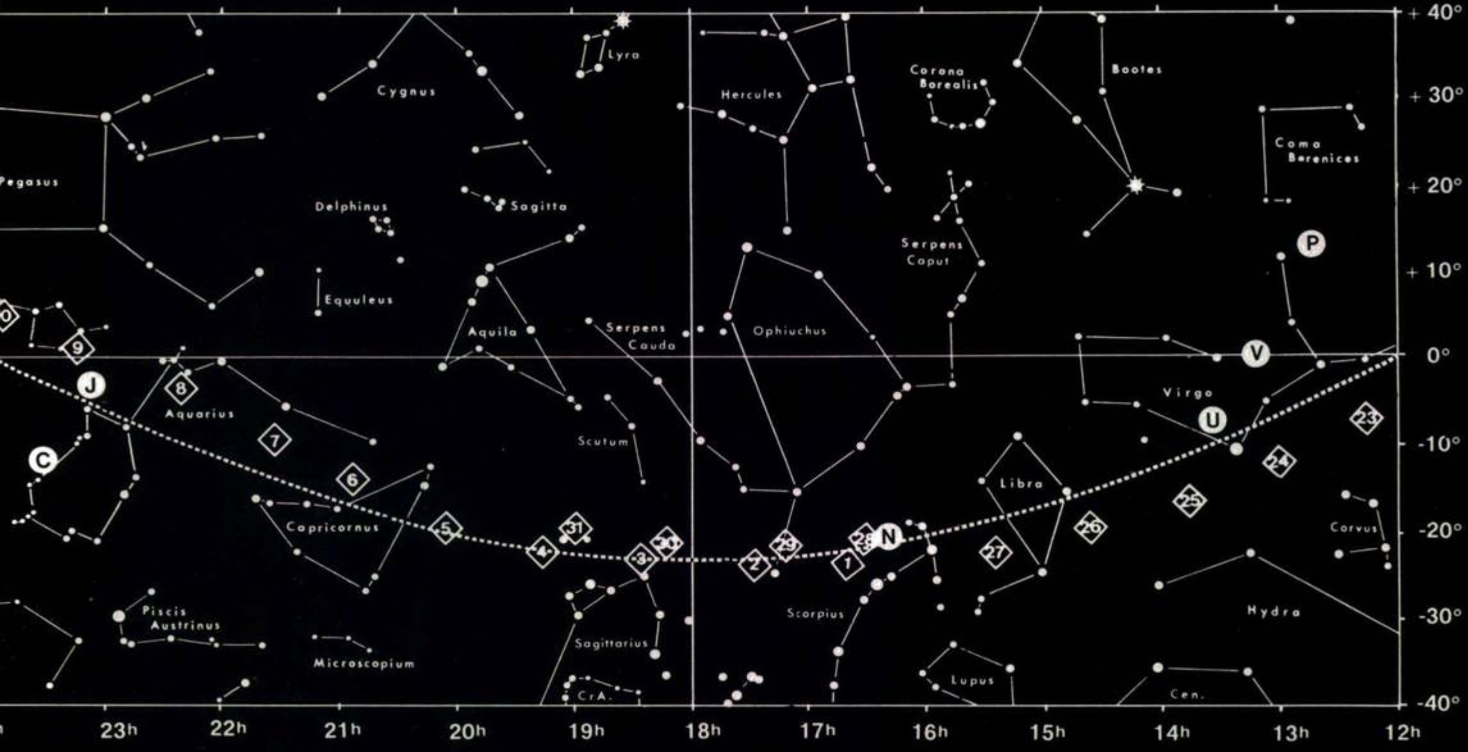
First Quarter
July 25



Full Moon
July 4



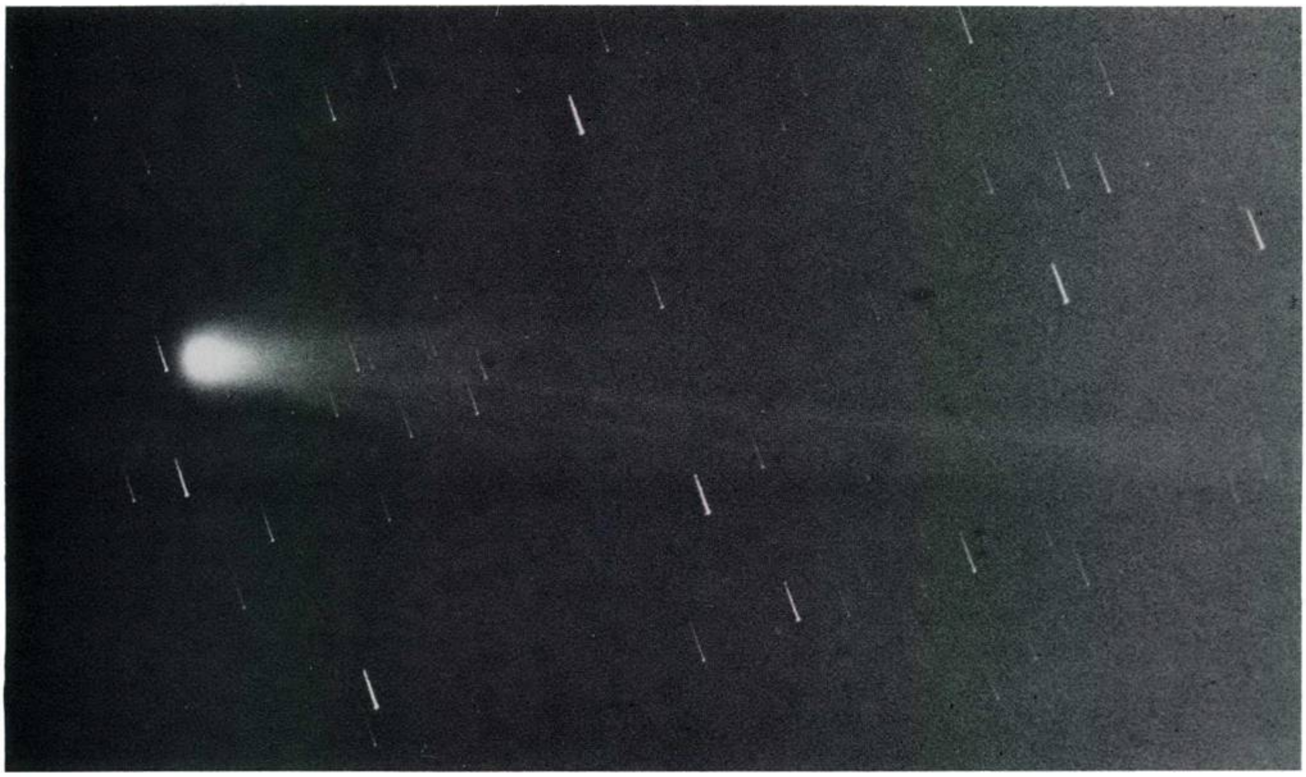
Last Quarter
July 12



+40°
+30°
+20°
+10°
0°
-10°
-20°
-30°
-40°
23h
22h
21h
20h
19h
18h
17h
16h
15h
14h
13h
12h
Pegasus
Cygnus
Lyra
Hercules
Corona Borealis
Bootes
Coma Berenices
Delphinus
Sagitta
Serpens Caput
Equuleus
Aquila
Serpens Cauda
Ophiuchus
Aquarius
Scutum
Virgo
Libra
Capricornus
Corvus
Scorpius
Hydra
Piscis Austrinus
Microscopium
Sagittarius
CrA.
Lupus
Cen.
J
C
V
U
P
N
9
8
7
6
5
4
31
3
30
2
29
1
28
27
26
25
24
23

Artwork by Victor Costanzo

measurement of the object's brightness. (The minus magnitudes indicate very bright planets.) **Dia.** = the planet's apparent diameter in seconds of arc. The diamonds with numbers within them indicate the position of the moon for each day of the month; the numbers correspond to the dates. Positions of the planets are for the 15th of the month except for Mercury and Venus which are shown on both the 1st and 15th.



Photograph by Terry D. Oswalt

Comet Bradfield's gossamer tail, extending about two degrees was captured in this 31 minute exposure with the 10 inch astrographic refractor of Indiana University. When this photo was taken on March 27, 1974 the crescent moon was only 8-1/2 degrees away producing a glare that brightened the sky background. Comet Bradfield was fourth magnitude around March 20, dropping to fifth when this photo was taken. From there it faded by about one magnitude per week during April. It is now an extremely faint object in Ursa Major.

merge with the moon so exact times are not really necessary. When watching for emergence of Venus look along the upper half of the moon's dark limb.

For telescope users the contrast of Venus' 12 seconds of arc, 86 percent sunlit disk near the moon will be remarkable. The moon — which always appears so bright — will look dull in comparison to Venus' dazzling face.

Using medium to high power on your telescope, you will be able to watch the moon actually pass over the disk of Venus until only a bright speck remains before final extinction. On the reappearance use medium to low power to keep the north half of the moon in the field of view while waiting for the first sign of Venus. As Venus emerges you may be able to see the dark peak of a lunar mountain profiled on the planet's brilliant face.

To avoid disappointment make sure you have an observing site with an unobstructed eastern horizon. Ten degrees is only the height of an outstretched fist; distant clouds and trees can be a hazard. The trees, at least, you can try to avoid by checking out your observing site in advance.

Venus

Low in the east Venus is our morning star for the summer. At magnitude -3.4, it is far brighter than any other planet or star. This month Venus presents a nearly full phase — 83 percent on the 1st and 90 percent by the 31st — as it recedes from Earth on the far side of its orbit. As the distance between planets increases from 124 to 139 million miles during July, Venus' diameter shrinks from 12.6 seconds of arc to 11.3 seconds during the month making our sister planet a small brilliant ball in the telescope.

Mercury

After its fine show last month, Mercury is back for an encore — but this time it's not quite as well placed for observing and it has shifted from the evening to the morning sky.

If you plan to be up for the Venus occultation on the 17th, you will find Mercury below and to the left of Venus and the moon by about one outstretched "handwidth". Mercury will be magnitude +1.1 that morning — much brighter than any nearby stars. On that same date Mercury will be a 23 percent crescent 8.9 seconds in diameter. For the following two weeks Mercury will be visi-

JULY 17 VENUS OCCULTATION TIMETABLE

Location	Disappearance	Reappearance	Remarks
	(times approximate)		
New England, Quebec, New York City area, New Jersey	5:00 a.m. EDT	5:45 a.m. EDT	Moon will be about 15 degrees above horizon at disappearance; sun just rising at reappearance.
Upstate New York, Pennsylvania, Washington D.C. area, Virginia, Ontario	4:55 a.m. EDT	5:40 a.m. EDT	Moon will be about 12 degrees above horizon at disappearance; sun just below horizon at reappearance.
Ohio, Indiana, Illinois, lower Michigan, southern Wisconsin, Kentucky, West Virginia, North Carolina	4:55 a.m. EDT 4:00 a.m. CDT	5:40 a.m. EDT 4:35 a.m. CDT	Note your time zone. Throughout these states moon will be about 8 degrees above horizon at disappearance; sun a few degrees below horizon at reappearance.
South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, Tennessee, Arkansas, Missouri, Oklahoma, eastern Texas	4:45 a.m. EDT 4:05 a.m. CDT	5:35 a.m. EDT 4:35 a.m. CDT	Note your time zone. In this region moon will be very close to horizon at disappearance; sun will be well below horizon at reappearance.

SATELLITE SHADOWS ON JUPITER

Date	Satellite	Transit begins (EDT)	Transit ends (EDT)
July 1	2	12:19 a.m.	3:11 a.m.
6	1	12:35 a.m.	2:50 a.m.
6-7	3	11:23 p.m.	2:51 a.m.
8	2	2:56 a.m.	5:47 a.m.
13	1	2:29 a.m.	4:44 a.m.
14	3	3:22 a.m.	6:51 a.m.
15	2	4:32 a.m.	8:23 a.m.
20	1	4:22 a.m.	6:38 a.m.
21-22	1	10:51 p.m.	1:06 a.m.
24	4	4:56 a.m.	8:56 a.m.
25-26	2	9:26 p.m.	12:17 a.m.
29	1	12:45 a.m.	3:01 a.m.
Aug. 2	2	12:02 a.m.	2:53 a.m.

1 = Io
2 = Europa
3 = Ganymede
4 = Callisto

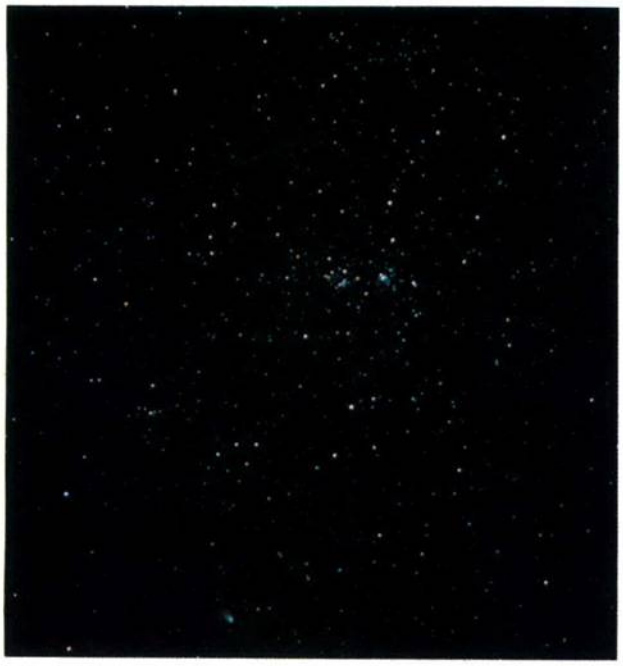
Photograph by Robert Campanile

A celestial traffic jam on April 18, 1974 included the crescent moon, Venus and Jupiter — the three brightest objects in the night sky (Venus is the brighter planet). The film was High Speed Ektachrome — a one second exposure at f/1.7 with a 55mm lens.

ble to any early risers who have time to look. By the morning of the 27th Mercury will have brightened considerably to magnitude -0.1 and its diameter will be 6.8 seconds with a 53 percent phase.

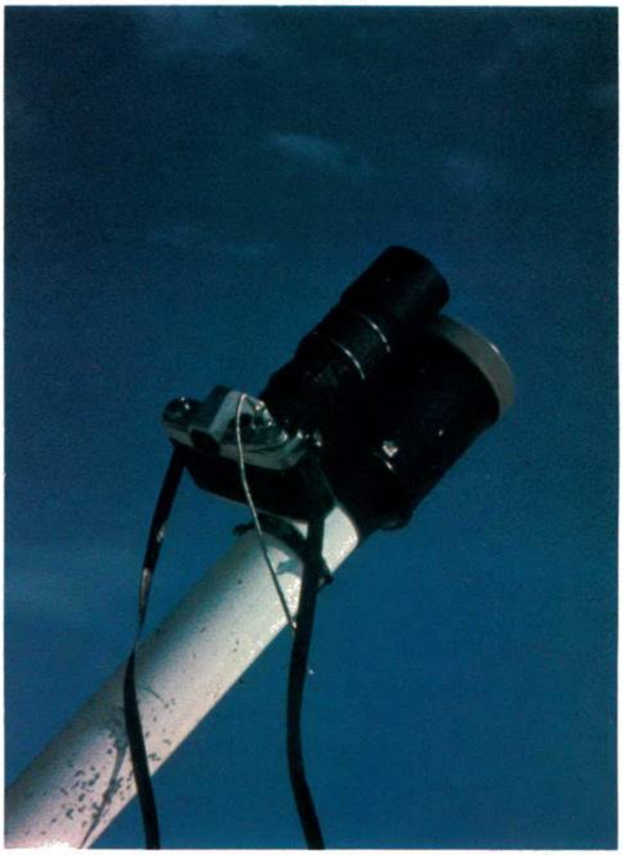
Jupiter

After midnight, any night in July, a brilliant star (magnitude -2.2) can be seen low in the southeast. The star is actually Jupiter, the giant of planets and a superb object for the astronomy enthusiast's telescope. Earth is closing the gap between us as we swing to a September rendezvous. Distance during July decreases from 421 to 386 million miles while the planet's apparent equatorial diameter expands from 40.5 to 44.2 seconds of arc. Satellite positions and satellite shadow transits are listed in the tables.



Photograph by Jack Newton

Comet Bradfield shared the sky with an artificial satellite and the "double cluster" in Perseus on April 13, 1974.



Photograph by Jack Newton

The photo of Comet Bradfield on this page was taken with the camera/telescope arrangement shown here. A 35mm camera with telephoto lens, attached to the upper end of the tube of a three inch refractor, tracks the stars because the observer keeps a guide star centered in the telescope's field of view. For more details, see page 43.

Mars

The red planet spends most of the month in obscurity at magnitude +2.0 in the dull constellation Cancer, low in the west after sundown. On the 25th and 26th, Mars will be within one degree of Regulus, the brightest star in Leo. Look for the two of them (Regulus will appear slightly brighter) on these dates very low in the west about 50 minutes after sunset. Now at the other side of its orbit, Mars appears as nothing more than an orange ball even in large telescopes.

Saturn

The beauty of Saturn and its rings is gone for most of July as the planet is in the region "behind" the sun as seen from Earth. On the morning of the 31st, however, you can get an interesting comparison since Venus and Saturn will be only 1/4 degree apart. This means they both will be in the same medium power telescopic field of view.

ASTRO-NEWS

Latest News From the World of Astronomy

Quasars Continue to Spark Controversy

All evidence points to the fact that we live in an expanding universe. Nearly 50 years ago Edwin Hubble discovered that all galaxies (except for a few nearby ones) are receding from us. He learned this from their redshifts — the displacement of the spectral "fingerprints" of galaxies from normal "rest" position to the red end of the spectrum.

Hubble found that the most distant galaxies have the greatest redshifts. But when quasars were discovered 11 years ago, their redshifts were found to be far greater than anything previously encountered.

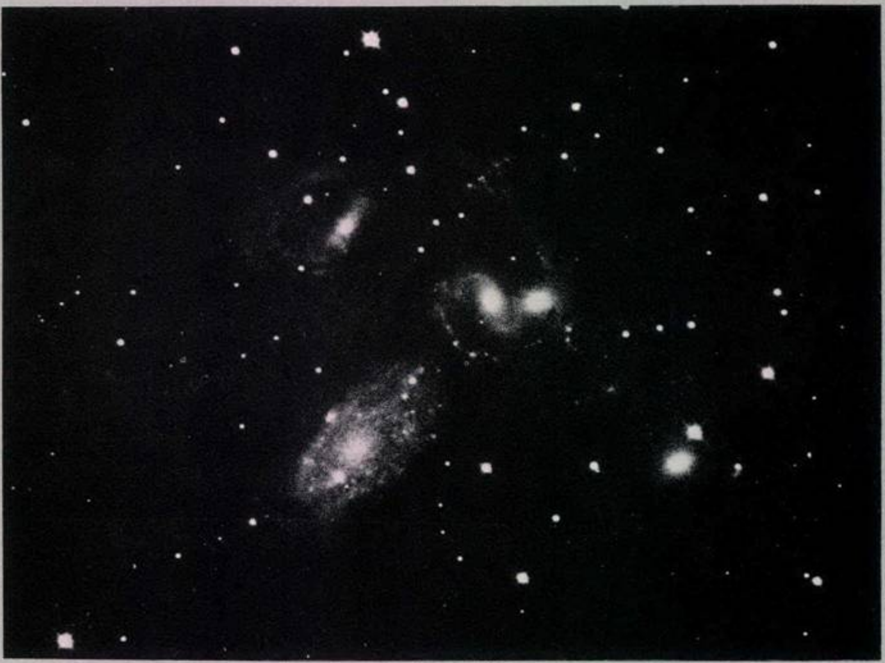
If quasars follow the same distance law as galaxies, they are among the most distant objects in the universe — some being several billion light-years away. They are also among the brightest objects in the universe, having an intrinsic luminosity which dwarfs many galaxies. Extreme distance, of course, also implies the remote past; quasars were apparently characteristic of an earlier stage in the evolution of the universe.

According to recent evidence (Astro-News, June 1974), quasars are some unexplained explosive event in the cores of apparently ordinary, and very distant, spherical galaxies. But the major problem still remains: What process produces the incredible energy required to generate the quasar's power output? This continuing energy crisis has led to rival theories that attempt to explain the enigma.

Chief opponents include Halton Arp and, not surprisingly, Sir Fred Hoyle, genial architect of the Steady State Theory of the Universe (which has as its basic assumption the concept that the large scale structure of the universe looks the same in all places and at all times). They have suggested that many redshifts may be explained by violent ejections of matter from nearer galaxies. This forcible expulsion has, in some unknown way, given certain galaxies and quasars redshifts uncharacteristic of their true distance. Arp has found a number of impressive examples of galaxies which seem to be associated with nearby objects that have aberrant redshifts.

One of Arp's principal cases is Stephan's quintet, a group of galaxies in which one member has an inordinately low redshift. Arp says each member of a close grouping of galaxies should have the same redshift since they are all likely to be at the same distance. But a recent *Astrophysical Journal* article by G. S. Shostak has called this apparent association into question. His observations of neutral hydrogen at 21cm show that the galaxy designated NGC-7318B and probably the galaxy NGC-7320C are at least 150 million light-years distant and cannot be associated with the anomalous low redshift companion which is known to be a great deal closer. This evidence

Quasars continued on page 28.



Lick Observatory Photograph

This group of five faint galaxies known as Stefan's quintet, has figured heavily in recent arguments about quasars as told in the article on this page. The problem is threefold: (a) a galaxy's red shift determines its distance, (b) a group of galaxies would logically be at the same distance, (c) one of these galaxies has a red shift far different from the others. Is the red shift due to some other mechanism that does not relate to distance? The debate continues.

First Phase of Global Weather Monitors

In a major step forward in the use of space observations to advance the science of weather forecasting, NASA has launched the first Synchronous Meteorological Satellite (SMS). The cylindrical, 1,379 pound spacecraft is now in position 22,591 miles over the equator at 45 degrees west longitude.

From its initial stationary position just off the coast of Brazil, the satellite will transmit electronic data to produce day and night pictures of the western hemisphere every 30 minutes; receive and transmit environmental information from up to 10,000 manned and unmanned data collection platforms; transmit and relay weather data and pictures to hundreds of small receiving stations, and monitor solar flare activity for future manned spacecraft and supersonic aircraft flights.

An onboard telescope will be able to produce 1/2 mile resolution images in visible light, and five mile resolution images at nighttime using infrared sensors.

In a companion experiment that is expected to get underway in Sept. 1974, 20 balloons will be released by the National Center for Atmospheric Research over a period of 90 days from the balloon launch site in French Guiana operated by the French National Center for Space Studies. The balloons will reach an altitude of about 100,000 feet and will float around the globe at the equator. Each balloon will carry transmitting and receiving equipment as well as 64 dropsondes (instrumented packages dropped by parachute), each weighing 14 ounces.

Working with both SMS and Nimbus F, a meteorological satellite to be launched this fall, the Carrier Balloon System will sample vertical wind data as well as temperature and humidity data at many points around the world as the dropsondes are released and drift to Earth.

Lifetime of the balloons, which will circle Earth every 15 to 25 days between 10 degrees north and 10 degrees south latitude, is expected to be at least 90 days and possibly as much as one year. The dropsondes will be released on command through the SMS from the control center at Wallops Island, Va. Two to four releases per day are planned. The tropic area was chosen for release of the balloons because there is a major gap in knowledge of equatorial winds which affect long-range forecasting capability.

The spacecraft will also monitor activity on the sun in real time to provide our first direct information on solar effects on the environment. Such information is expected to be especially useful to warn manned spacecraft and future supersonic aircraft of potential solar radiation dangers. Also it is expected to be used for radio communications blackout alerts. Past studies have shown satellite data is at least 10 times as accurate in picking up small solar flares as ground based equipment.

In the late 1970s, the European Space Research Organization (ESRO), Japan and the Soviet Union are expected to join the United States in providing meteorological satellites in synchronous orbit. The spacecraft will be about 70 degrees apart, spaced around the world. The U.S. satellites then will cover the western hemisphere; ESRO's satellite will observe Europe, Near Eastern areas and Africa; the Soviet spacecraft will cover the Soviet Union as well as other parts of Asia and India, and the Japanese will close the global system with a spacecraft monitoring the Far East and the western Pacific Ocean. All except the Russian spacecraft are planned to be launched aboard Delta vehicles from Kennedy Space Center, Fla.

Animal Monitor Soon to Orbit

The dwindling populations of rare species of large and exotic animals will be monitored by NASA's newest Nimbus satellite, to be launched later this year.

Elephants in Kenya, elk and grizzly bears in Wyoming and a polar bear in the Canadian Arctic have been fitted with small transmitters. The satellite will receive the transmissions allowing accurate tracking of the animals' migratory wanderings.

This information may be useful in some future attempts to stabilize the declining populations of these beasts that share our planet.

As I begin to write this, I am alone with my thoughts under a starry equatorial sky — the splendor of which makes writing about it seem almost too human. I have driven to a spot some 15 miles outside Nairobi, the capital of Kenya, East Africa.

My own interest in the heavens began as a youngster living in Edmonton, Canada, located some 54 degrees north latitude — a drawback to the most enthusiastic amateur astronomer. The long twilights during the summer — when one *could* stay up late — ruled out most stellar viewing. And in the wintertime, the equally long hours of darkness were accompanied by bitter cold, and even worse — homework; however, there was still enough time, usually in the spring or autumn, to pursue the study of the stars with buddies who have become lifelong friends.

Only a fraction of the entire firmament was visible from Edmonton, again by virtue of its northern latitude. (For example, only part of Sagittarius could be seen — and at that, only for a short period — creating an annual and predictable flurry of activity among youthful Messier hunters.)

Perhaps motivated by this seemingly unjust denial, I become increasingly fascinated by the legendary vault of stars forever hidden beneath — and beyond — the southern horizon. Like exotic, tantalizing pictures in a geography book, the southern sky seemed unattainable — except vicariously through the black and white medium of star maps, which I recall studying as arduously as maps and pictures of faraway lands on Earth I dreamed of visiting someday. And I realize now that there must have been a connection between these otherwise seemingly different interests.

In time my travels to other lands would begin, and on an early journey through Mexico, I'll never forget the thrill of seeing the bright red star Canopus for the first time. I suppose it was like seeing a movie star in person whom you've allowed yourself to think of as a friend. This is the first time I've admitted it, but I whispered "Hello, Canopus" — and I recall having a tear in my

Night Thoughts

Kenya, Jan. 28, 1974

Guest Opinion by Ian McLennan

eye. I have seen Canopus too many times now to shed a tear whenever I see her, but tonight, looking at that beautiful star (so astonishingly high above the horizon!), I said a quiet "Hello" as usual. And when I leave this country in a few days to return to the reality of a northern winter, I will say a quiet "Goodbye for now" with the same sincerity (and trust) that characterizes the "See you again soon" one might utter as an understatement to a departing friend.

My first visit to Kenya was only seven months ago. It was to observe and direct the filming of the incomparable spectacle of last June's total solar eclipse. At a lonely outpost on the shore of Lake Rudolf in the northern Kenyan desert, ferocious winds had caused our tent to collapse during the night and our party was forced to sleep outside in a combination of darkness and howling fury that would surely have appeared contrived in a movie recreation.

As I lay gazing into this truly scary situation, the canopy of stars would appear now and then, but would be quickly obliterated by high altitude dust clouds — which had the astonishing effect of propelling me *through* interstellar clouds of dust and gas — an illusion heightened by some unfamiliar groupings of stars as seen from the equator, not to mention the lack of a horizon reference. When it did clear up, even momentarily, the appearance of the Magellanic clouds, the sensuous diamondlike quality of the Southern Cross, and, of course, Her Majesty the southern Milky Way, were sights to relegate the acknowledged Wonders of the World for a now seasoned traveler to a low order of magnitude.

And what a contrast this peaceful January night! In the solitude of this location, the subtle color changes among the stars are much more prevalent. I am reminded of the thought I had only half a year ago (since one can literally observe the entire firmament from the equator) that it would be wonderful to return in half a year's time to catch the whole show — and quite unexpectedly here I am.

How strange (indeed what fun!) to see Orion high in the northern sky and to go through intricate body contortions to see him "the right way". Sirius is as brilliant this night as Venus appeared two weeks ago in Toronto, Canada, and by contrast I notice the delicate but unmistakable outline of tiny Sagitta, the Arrow. Despite a not insignificant glow from a distant neon sign (whose energy has come from one among these myriads of stars) I can clearly distinguish the distinctive arm and crystalline structure of the large Magellanic cloud. Looking back toward the sign and reflecting on Carl Sagan's *Cosmic Connection*, it occurs to me that it would be interesting to know what some other civilization in space is doing with its supply of neon this night... an almost arbitrary mixture of Earth thoughts and space thoughts. And just now, an unseen batlike creature, mocking the limitations of my senses, can be heard flitting about overhead — and for some reason its eerie sounds appear to be exactly halfway between me and infinity.

Saturated with such thoughts (perhaps afraid of too much?) I eventually decide it is time to leave. Still transfixed by the subtle extravagance of the experience, I thoughtlessly get into the left-hand side of the rented car. And I'm immediately faced with the awkward reality of not being able to drive without a steering wheel which, of course, happens to be on the right-hand side of the car. It's a silly moment of comedy superimposed over thoughts that embrace all of time and great celestial events. Chuckling audibly to myself, I re-emerge into the darkness of the night — and I am rewarded with the sight of a greenish-yellow meteor that slices the sky in two. It leaves a brief, lonely signature in the atmosphere of the planet preordained by the intricacies of cosmic orbits to consume it. Am I alone in witnessing this cosmic moment? Or has someone, somewhere, shared it with me? I am unable to answer, even as a secret to myself, which I prefer.

Returning to Nairobi, I ponder the various immediate destinations of the passengers in vehicles whose headlights are swishing by me — all these destinations, like that of the meteor, being microscopic parts of man's cosmic destiny, whatever that may be. A passing oil laden tanker truck carrying fuel from the ships of Mombasa gives rise to a mundane thought about the so-called energy crisis... and I think back to the total amount of energy I've looked at tonight. Man's pitiful stance in the cosmic scheme of things appears more amusing than perplexing or distressing.

In the rotunda of the Nairobi Hilton, tourists are returning from their various guided tours in zebra-striped Volkswagen buses. Some have bought expensive safari outfits for the occasion. A few fidget with cameras that have recorded *their* impressions of Africa.

In the background, I hear amplified sounds of an imported Broadway revue emanating from the hotel night club; the show is advertised as having "a distinctive Afro sound". One of the tour leaders exclaims, "Time for lights out!" Does he know what that could mean — what lights out in downtown Nairobi would reveal overhead?

Would they look?

So I muse about some future tour operator including in his African brochure an exploration into the sights (and thoughts) afforded me this night, and I experience a mild sense of relief that it likely won't happen....

Unlike the jungles, rivers, deserts, mountains, even exotic cities and entire human cultures that have succumbed to the exploitation of the packaged tour, the pure and majestic sky is the last and most appropriate domain for private communion with something that is unreachable, yet part of us all.

Goodnight, Canopus.

Ian McLennan is general manager of ONTARIO PLACE, an expo-like recreation/entertainment center in Toronto, Canada; he was formerly executive director of the Rochester Museum and Science Center, Rochester, N.Y. In the 1960s McLennan gained an international reputation for his innovations in planetarium design and production techniques while he was director of two major planetariums and acting as a consultant for many others. His recent trips to Kenya have resulted in a film of last year's total eclipse that will soon be featured at ONTARIO PLACE.

Mysterious Glow Above Saturn's Rings

In these days of radio telescopes and electron microscopes it's not often that an amateur scientist can make a contribution to scientific knowledge. But this seems to have happened on Oct. 17, 1973 while a group of Canadian amateur astronomers, observing near Edmonton, Alberta, watched the moon pass in front of the planet Saturn.

The event, known as an occultation, was nearing an end — the moon had been in front of Saturn for several minutes and was just about to allow the planet to reappear.

The observers knew the rings would appear before Saturn itself, and they knew exactly where to watch for them — a predetermined point on the dark edge of the night side of the moon.

About two seconds before the tip of the rings appeared, one of the observers, Glen Reed, noted a faint glow like "a campfire on the other side of a treeless hill on a dark night". The other members of the group were busy preparing to photograph Saturn and missed the sighting.

When the rings finally did emerge from behind the moon, their glow washed out the faint aura that seemed to extend beyond them. This observation is quite unique and, if substantiated, will mark a significant finding for an amateur astronomer.

If the glow is real it means that Saturn's rings have an "atmosphere" of some unknown characteristic. Perhaps the rings extend, in a rarified form, beyond the denser bright rings seen in photographs of the planet. Sunlight reflected from these particles may be visible only when Saturn itself is hidden (as was the case last October during the reported observation).

Unfortunately there will be no more occultations of Saturn visible from North America for several years, so confirmation will have to wait.

Meanwhile the exact nature of the famous rings is still hotly debated. At a recent meeting of planetary scientists in San Jose, Calif., evidence was presented showing that the ring particles must be dust size pieces of sand and ice. But other astronomers made equally convincing presentations that suggest the particles are boulder size and larger.

Ice fits into most of the theories, but the density of particles and proportions of other elements is open to debate.

Some answers will come in 1979 when Pioneer 11, if it is still working, will fly past Saturn and record our first close-up pictures of the planet and its fascinating rings.

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Mariner 10 to Return to Mercury

Mariner 10, the first spacecraft to Mercury, hurtled past the sun-scorched planet in March 1974 giving earthlings their first close-up view of what was, until recently, an unknown world. On May 9 and 10, a complex adjustment in the path of Mariner 10 was successfully completed, assuring a second flyby of the solar system's smallest planet.

On the first encounter, Mariner 10's cameras recorded a desolate battered landscape pitted with as many craters as our moon. Apparently the same forces that blasted out the moon craters — presumably chunks of space debris ranging up to mountain size — were responsible for gouging out the features on Mercury. This suggests that Mercury has a history similar to the moon's and has therefore remained basically unchanged for the last three to four billion years.

The unprecedented second look, due Sept. 21 thanks to the successful trajectory maneuver, will yield up to 1,000 photos of the planet in addition to the 2,000 obtained on the first encounter.

The dual mission capability stems from Mariner 10's orbit around the sun which takes 176 days to complete. Mercury will have swung through two of its orbits in the same period, bringing the spacecraft and planet to a second rendezvous. Mercury also completes its 176 day rotation during the interval so Mariner will see the same illumination of the same surface features, but from entirely different angles.

The spacecraft is targeted to pass 46,000 miles above the 65 degree south latitude point on Mercury's sunlit side. This will give a clear view of the south polar region and the part of Mercury that will be facing toward the sun — both zones not well seen during the first flyby.

Quasars

continued from page 25.

thus supports the idea that quasars are as far away as their redshifts indicate.

Although the body of astronomical opinion continues to lean toward the traditional view (that quasars are indeed very remote), the battle is not yet over — for yet another explanation for quasar redshifts has been proposed that suggests that there are, in fact, no redshifts in quasars at all! Instead we may be getting an illusory effect produced in a new class of star-like objects in our galaxy.

This concept, proposed by Y.P. Varshni at a recent meeting of the American Astronomical Society (AAS), suggests that there are several basic spectral lines produced in this class of stars, and in one star one set of lines may be bright. This is due to a process known as stimulated emission and is similar to the processes occurring in optical lasers.

If the lines observed in quasars are laser emission lines, then their occurrence or absence depends only on the physical conditions within the object and not on its redshift. Astronomers might be mistakenly trying to account for the observed emission lines as redshift features.

There are still many controversial aspects of this new model which need to be settled, but Varshni's talk at the AAS meeting was favorably received and closely examined. Only time will tell whether the new theory can stand up to criticism. Recently there has been a lot of wild speculation on the nature of quasars and we can only wait and see which models survive rigorous examination. If this new model turns out to be correct, then we are left with the discovery of a new class of objects in space which is not yet understood. However, the severe energy problems usually associated with quasars would be lessened if the objects are in fact in our galaxy, as Varshni suggested.

"Rust" in Lunar Dust

Scientists at the Naval Research Laboratory (NLR) studying lunar soil samples returned by Apollo astronauts say lunar soils contain magnetite, an oxide of iron that is related to rust but is black instead of orange, and has much stronger magnetic properties.

The occurrence of either rust or magnetite in lunar samples would imply that some oxidation has occurred either on the moon or after the samples were returned to Earth. Because of the apparent absence of significant amounts of oxidizing agents at the lunar surface, such as air or water, many lunar scientists have discounted previous observations of "rusty moon rocks" as accidents which happened to the samples after being exposed to a humid atmosphere on Earth.

NRL investigators say, however, if magnetite exists in the lunar soils, this "accident" explanation is not applicable, since magnetite requires high temperatures to form. Other scientists have noted that small quantities of water form at the lunar surface when hydrogen, arriving from the sun via the "solar wind", reacts chemically with some of the oxygen which is normally present in the exposed moon rocks and soil.

Laboratory experiments indicate that some of the dark colors of the moon, as seen from Earth, may actually result from the presence of very tiny particles of magnetite in the older lunar soils. The NRL theory may resolve the long-standing riddle of why the oldest lunar soils are always darker than the moon rocks from which they were produced by the crushing action of meteorite collisions.

NRL scientists believe that not all of this water escapes into space as previously suggested. Instead, they say some of it has time to react with the soils during high temperature meteorite collisions, thus forming some magnetite. These magnetites may be responsible for some of the magnetism of lunar rocks and, therefore, may hold the key to understanding the moon's magnetic past.

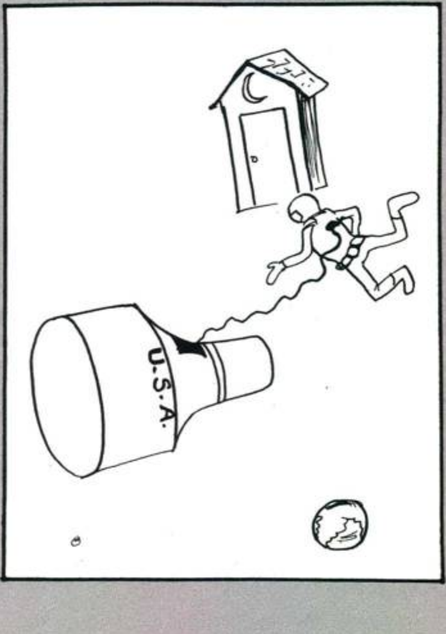
Space Colonies Taken Seriously

Earth, by the year 2075, could be a global park where people go for vacations or live in retirement while all heavy industry is conducted in outer space according to an internationally renowned scientist.

Dr. Gerard K. O'Neill, professor of physics at Princeton University, told a recent gathering of space scientists that dozens of "small" colonies of about 2,000 people each could be locked in orbit about Earth at an equal distance from both Earth and the moon.

The advantage of this location is its permanence. Certain asteroids called Trojans have been orbiting at an equal distance from the sun and Jupiter for millions of years.

O'Neill pictures cylinder shaped space "cities" that rotate to produce artifical gravity. "The first such city structured would be the hardest", he said, "because much of the material for it will come from Earth." Later he envisions most of the construction material coming from the moon.



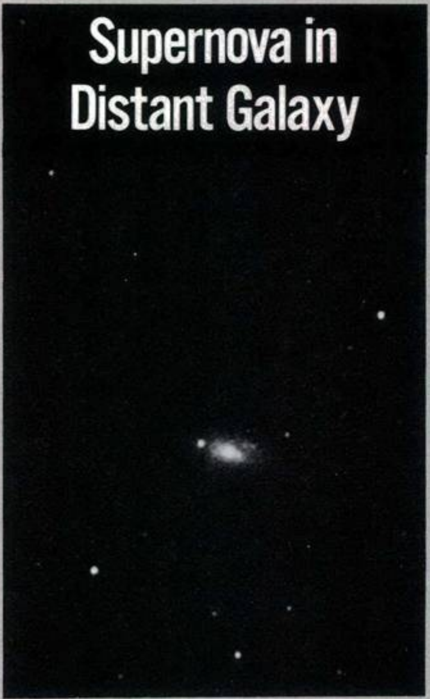
He proposed a unique method for getting mined moon metals that involves a lunar slingshot. The device would be an eight mile long track that could be built up the wall of a large crater. By passing a strong magnetic current along the track — a relatively easy feat on the airless moon — a capsule of pure titanium, for example, could be accelerated to escape from the moon's gravity. The capsule could then be maneuvered with little effort to the "gravity-lock" position of the colony.

Titanium, an abundant metal on the moon's surface, is a superb building material. Over 13,000 tons of it could be ejected from the moon each year under O'Neill's plan.

The proposal got mixed reactions from the scientists present. But they readily admitted that mining valuable minerals from the moon or other bodies, and getting it safely to the surface of Earth, is far more difficult than O'Neill's proposal of using it in space where "a baby can lift a 1,000 ton steel girder".

This conference marked one of the first occasions where the idea of a mass exodus from Earth has been treated in a serious academic way. One reason for the new respectability was the success of the Skylab program that demonstrated conclusively that man can survive for at least three months in space and probably much longer under artificial gravity conditions.

Supernova in Distant Galaxy



Photograph by Jack Newton

A monstrous supernova explosion, signaling the destruction of a large star, is nearly as bright as the entire galaxy of which it is a part. The galaxy is the 10th magnitude NGC-4414. The supernova is the bright star just to the left of the galaxy's bright central region. The last known supernova in our galaxy was visible in 1604 and was as bright as Jupiter. An earlier one in 1572 exceeded Venus in brilliance. Photo above was taken on May 17 with a 12-1/2 inch f/4.3 reflector.

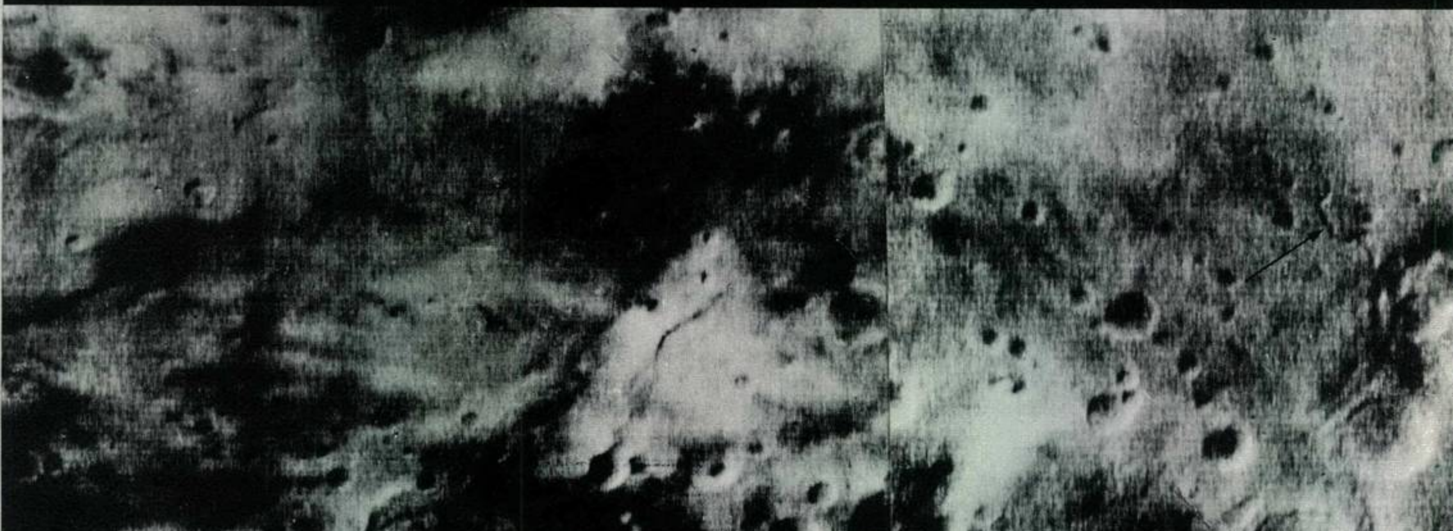
Black Hole Alternative

Probably the most bizarre objects in the known universe are the gravitational whirlpools known as black holes. They are theoretically formed during the death of a huge sun. As a massive star collapses under its own weight, when its fuel reserves are exhausted, it crushes itself out of the universe leaving only its gravitational field behind. As reported in detail in the March 1974 issue of ASTRONOMY, the binary star Cygnus X-1 is believed to have a black hole as one of its components.

Now, J. N. Bahcall, F. J. Dyson, J. I. Katz and B. Paczynski writing in the *Astrophysical Journal* suggest the same characteristics can be produced by a three-body system consisting of a normal B main-sequence star, a supergiant, and a neutron star. They note that a significant fraction, perhaps 20 percent, of all stellar systems are triple at least — so the model is far from radical. It would thus appear that multiple star models need to be considered more fully before Cygnus X-1 can be possitively regarded as a black hole.

"DO WE HAVE TO TALK ABOUT YOUR WORK AGAIN TONIGHT, HAROLD!"

THE VIEW FROM MARS 5



This 2,000 mile wide panorama of Mars shows a vast area centered on Mare Erythraeum in the planet's southern hemisphere. The arrow identifies a mysterious channel thought to be carved by water. (For a close-up photo of this channel taken by Mariner 9, see page 10 of ASTRONOMY, April 1974.) Craters dot the landscape ranging from 100 mile diameter basins to 5 mile wide features near the limit of resolution.

Unexplained Gamma Ray Signals Studied

It all began in 1963 when the United States and Soviet governments independently decided that some device was needed to monitor the other side to make sure the weapons testing treaty was not broken.

The U.S. Air Force developed Vela satellites that were placed in Earth orbit in the mid-1960s. The Vela series was continually improved until they were capable of detecting a nuclear detonation on the far side of the moon. To be so sensitive, the satellites were loaded with X-ray, neutron and gamma ray detectors.

When the Limited Test Ban Treaty on nuclear weapons was signed in 1963, no one had any reason to believe it would lead to the discovery of strange signals from some, as yet unknown, source in outer space. But that's exactly what has happened and astronomers are excited and puzzled by the new findings.

Top flight scientists were recruited to design these devices, as happens in many military projects. One of them, Dr. Ian B. Strong of the Los Alamos Scientific Laboratory, N.M., described findings of the project at a recent gathering of scientists in San Francisco.

"Remarkably, blasts of gamma rays — not from bombs but from deep space — were detected at irregular intervals," said Strong. "We determined the gamma rays were not coming from any known object in the solar system, including Earth and the sun."

But what emits these unexpected gamma ray signals?

Strong believes they are very small sources, possibly no larger than Earth. "Yet to equal their energy release we would have to cover the entire land and water surface of Earth with shoulder-to-shoulder hydrogen bombs!" he said.

"They are scattered apparently randomly over the sky," explained Strong. "This tells us that either they are relatively close and in our galaxy, no more than a few hundred light-years away, or they are far beyond our Milky Way galaxy."

Among the sources proposed to explain the energy release is the formation of gravitational black holes. These cosmic gravity pits are the end product of a supernova explosion — the violent death of a large star. Other astronomers propose flares, like the sun's, erupting from small dense stars called white dwarfs. Still others say the gamma rays could come from neutron stars — tiny dense stars that weigh a billion tons per cubic inch — that become unstable and collapse into black holes.

No one suggested the signals could be from intelligent sources. "They seem to be too random and too wasteful for any intelligence," said one scientist. But Dr. Sterling Colgate, a noted theorist in the field, said, "Probably all the ideas so far put forward are wrong."

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Aurora over Equator

To Canadians and residents of the northern U.S., the shimmering Aurora Borealis, or northern lights, are a rare but well-known phenomenon. But until recently they were believed to be limited to near-polar regions. So when radar studies from Peru detected upper atmospheric disturbances characteristic of auroras, an investigation was mounted.

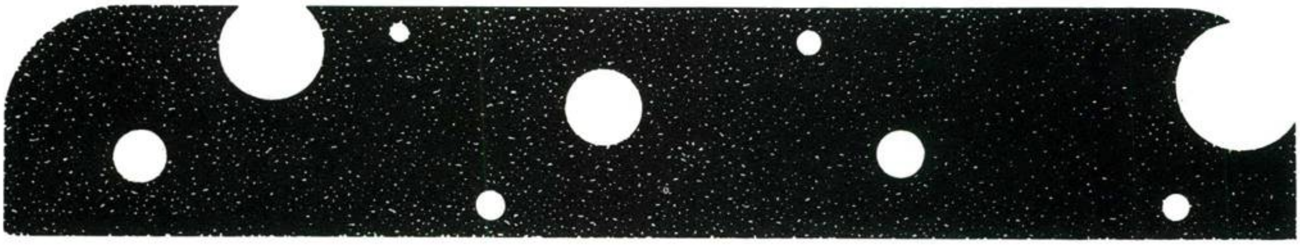
Firing a small rocket to an altitude of 447 miles, U.S. and Peruvian scientists used sensitive instrumentation to detect auroral activity between 124 and 310 miles up. Although it is there, the aurora is too weak to be visible from the Earth's surface.

Frozen 10,000 Years, Bacteria Thrive

A search for living organisms in Antarctica has turned up frozen bacteria at least 10,000 years old that grow and reproduce when exposed to warmth and food. The bacteria, found buried under 250 feet of ice and soil, were transferred in sealed drill cores to NASA sponsored laboratories in the U.S. where they were brought out of hibernation in sterile conditions.

The experiment has significant implications for the Viking life detection landing mission to Mars. Some theories suggest that Mars periodically has a climate capable of sustaining primitive life. We are currently not in such a regime on Mars, but according to some theorists life forms may be hibernating — just as those in Antarctica.

Viking is due on Mars in July 1976 and has the capability of detecting bacteria that may be in the first few inches of Martian soil. It's a long shot experiment by most estimates but one that is deemed worthwhile in view of man's long-time interest in life on Mars.



STELLAR FRONTIERS

What Radio Eyes Would See

by

Gerrit L. Verschuur

What would the sky look like if we had "radio" eyes? If instead of seeing that we call visible light, we could tune our eyes to detect the radio radiation that floods through space — what would it look like?

Orion would be gone as would Cygnus, Sagittarius and Scorpius — all the familiar constellations would be invisible. A new vista of eerie radio stars would be strung in a celestial necklace across the sky near the zone where the Milky Way once was. Beyond that band, other radio sources would dot a darkened cosmos.

But what are radio sources anyway, and how are they located if our eyes can't detect the sky's radio signals?

Forty years ago a crude radio receiver, constructed to detect the source of interference hampering transatlantic telephone links in the 1930s, picked up a hiss that appeared to be coming from the Milky Way. A few years later Grote Reber, the radio amateur, confirmed this discovery and showed that the strongest hiss came from the direction of Sagittarius behind which lies the center of our galaxy.

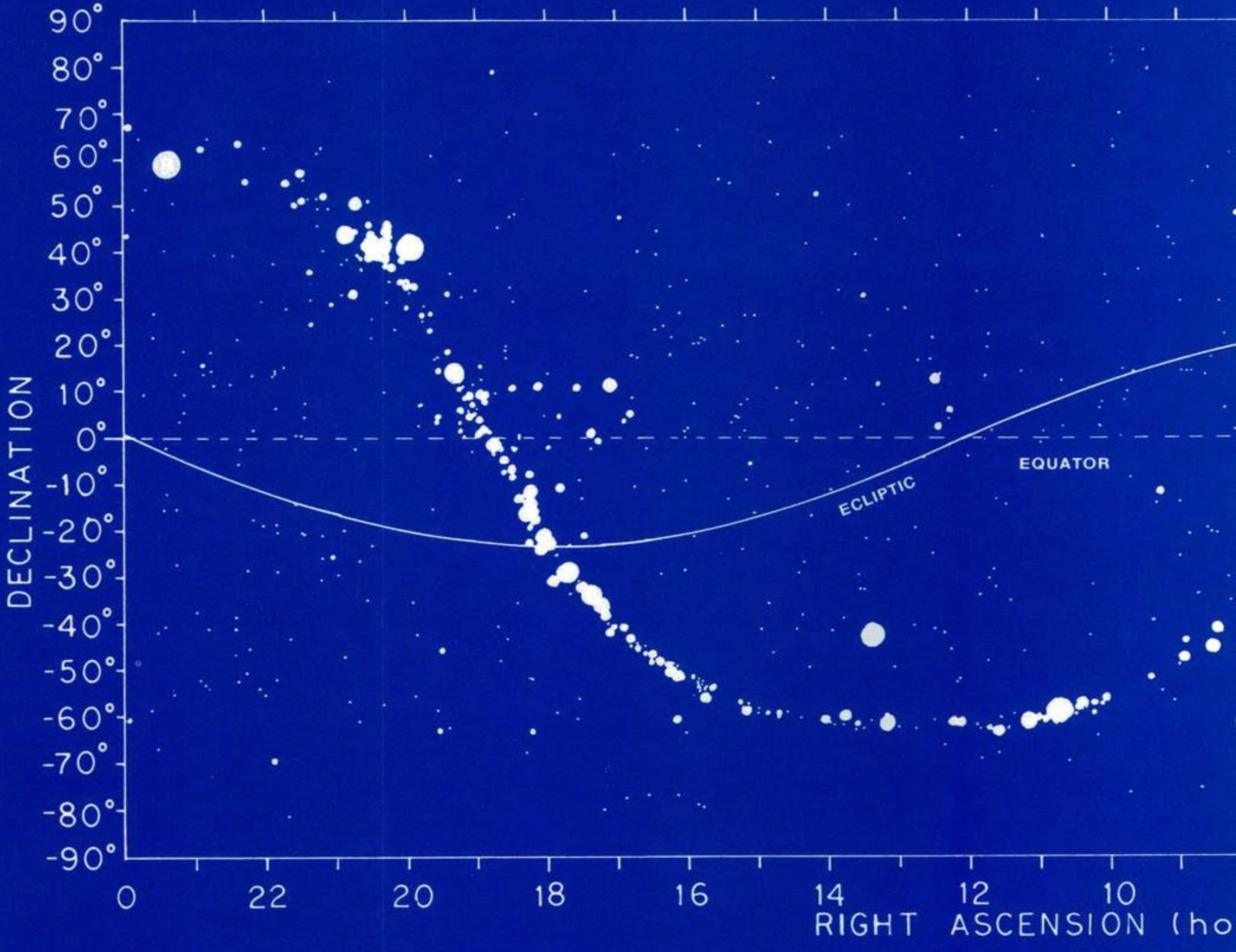
Twenty years later astronomers finally had a good theory for the origin of this radio hiss. It is produced by cosmic ray particles — electrons traveling at nearly the speed of light — spiraling about the magnetic fields that thread their way through all of our Milky Way. When a radio telescope capable of detecting these weak radio signals is pointed at the Milky Way, it picks up the maximum amount of this radio emission. When it is pointed away from the Milky Way, very little emission is received.

By scanning the sky systematically with a giant radio telescope, the radio astronomer can make a map of the direction from which radio signals of different intensities are being received. Such maps are drawn in the form of contours indicating the strength of the received signals coming to us from outer space. Contours of increasing signal strength would look just like contours indicating different elevations on a topographical map. Therefore, when examining a map of the radio sky, you can identify the presence of strong sources of radio waves from space because they appear as "mountains" on the maps.

The earliest radio maps of the sky showed a broad belt of radio emission closely following the outline of the hazy band of light that we call the Milky Way. The highest radio contour levels on

The constellation Cygnus completely loses its identity when seen in "radio eyes". The familiar visible stars (faint gray) are invisible in this 20cm wavelength view. An entirely new group of radio stars emerges where the "northern cross" is seen by our eyes. What new myths would arise if we were to see the radio sky? This article explores that sky — unseen by human eyes.

Artwork by Victor Costanzo

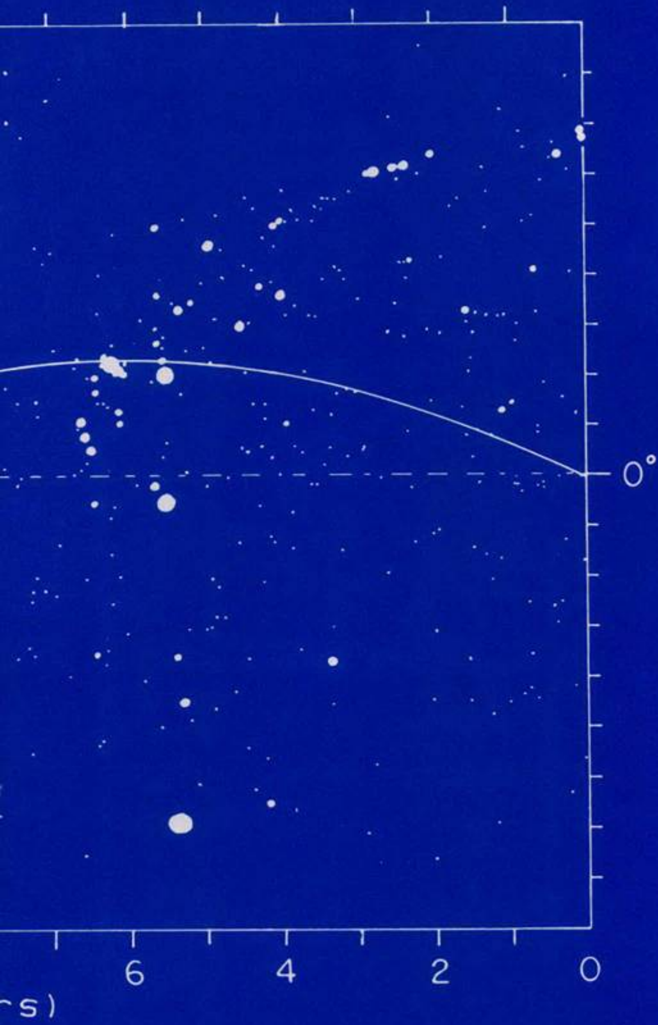


All the familiar constellations disappear in this map of radio sources that would be "seen" with radio eyes. Compare the celestial coordinates of the constellations on the chart on page 20 with these radio constellations. The crowding along the Milky Way is due to the penetrating power of radio waves which cut through clouds of gas and dust that block much of

these maps are found in the direction of the constellation Sagittarius. But beyond the limits of the Milky Way the maps showed many small "hills" that seem to be spread randomly over the sky. These are the so-called radio sources. Photographs of these areas reveal some "hills" to be well known objects, such as supernova remnants (the Crab nebula) or peculiar galaxies (like M-82). But at the position of many other radio sources just a faint star is seen. After the discovery of quasars in 1963, some of the radio sources turned out not to be stars at all, but quasars masquerading as stars. However that didn't explain all of them, for even now many radio sources are known to exist where absolutely nothing is visible on a photographic plate.

Radio signals are generated by different physical processes in different objects in the universe. While one object may be a strong emitter at a short wavelength, another might be a strong emitter at a long radio wavelength. (Stars do the same thing in visible light; hot stars emit much of their energy in short wavelengths and appear blue to the eye while cool stars, emitting energy at longer wavelengths, seem red.) The result is that the radio sky looks quite different at different radio wavelengths.

If we imagine that we have radio eyes and that a strong radio signal is the same as a bright



this region in visible light. The map shows only the 20cm region. A map of the radio sky in all wavelengths has not yet been made.

Diagram by G. L. Verschuur

light source, then we would see the radio sky as a whole lot of "stars" in the sky with a bright band of them where we normally see the Milky Way. We will see this at a radio wavelength of say 75cm (one of the radio astronomers' favorite wavelengths). If we could shift to 40cm wavelength, we would see basically the same set of stars but their relative brightnesses would have changed. In addition, the band of the Milky Way would have become narrower. Instead of being about 20 degrees wide (as it was at 75cm), it would be about 10 degrees wide. At 20cm wavelength, we would see that the Milky Way was even thinner — only three or four degrees wide. At all these wavelengths the Milky Way in Sagittarius would be the brightest, while toward Taurus it would be much less obvious.

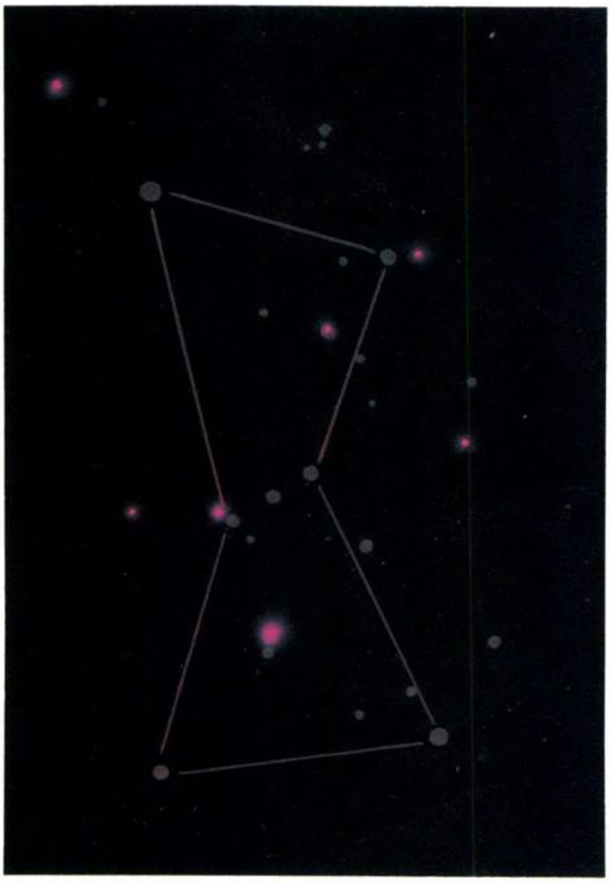
If we tuned the wavelength, to which our eyes were sensitive, all the way down to 2cm, we would find the Milky Way hardly visible at all. Instead, we would see many very bright spots all along the Milky Way (or at least along the line where the Milky Way would have been). These bright spots are some of the nebulae and supernovae which are still clearly "visible" while the emission from the Milky Way itself (the emission from the cosmic rays spiraling around interstellar magnetic field lines) has become very faint.

And what would we see if we tuned our radio eyes to a wavelength longer than 75cm? First, the width of the Milky Way would balloon until the whole sky is filled with emission. The emission is still strongest along the Milky Way band itself, but now — even at the galactic poles — there would be brightening of the whole sky. A typical wavelength at which this might be seen would be about 150cm.

If we were to look at the radio sky at an even longer wavelength, something strange would start to happen. The Milky Way would become darker and darker until, at a wavelength of 30 meters, the sky would be bright everywhere except in patches along the Milky Way. There we would see regions of varying darkness, much like patches of obscuration produced by dust clouds. A few starlike points of light would be seen spread over the rest of the sky, but these would be mostly washed out by the brightness of the sky. At 100 meter wavelengths, the Milky Way would be a dark band stretched across the sky.

These dark patches are produced by clouds of low energy electrons — really just hot gases — compared with the high speed electrons that make up the cosmic rays. These clouds of thermal electrons, as they are called, now absorb the radio signals produced by cosmic ray electrons. At these very long wavelengths one also finds that some of the distant emission nebulae, visible as bright spots in the sky at short wavelengths, now become dark holes absorbing all the radiation originating beyond them. To someone with radio eyes, then, the sky at long wavelengths would always be bright and there would be no day and night! The sun, of course, would shine at all wavelengths and would continue to dominate the sky in terms of its brightness.

Probably the most comprehensive surveys of the sky so far have been made at a wavelength of 20cm. Let's see how the sources of radio emission, apart from the glow from the Milky Way, are distributed over the sky at this wavelength. On this page we have plotted the location of all the



Artwork by Victor Costanzo

In radio eyes, Orion is gone except for the Great Nebula which shines at first magnitude on Verschuur's radio scale. Orion is much duller at 20cm wavelength than in visible light. But Cygnus (page 33) is brighter in radio than in visible.

sources found so far at 20cm. The symbols used were chosen as follows:

In order to draw a parallel with the sky which we actually see at night, we have attributed a "luminosity" scale to the radio sources which mimics the optical system. The brightest visible star, Sirius, has a luminosity or magnitude of -2. We therefore assigned the brightest radio source, the supernova remnant Cassiopeia-A, a radio magnitude of -2. This is quite arbitrary since radio astronomers measure the brightness of radio sources in terms of flux units (or Janskys, as they are now called). A slightly different size circle was drawn for sources of successively lesser magnitudes and the map was cut off at "magnitude" 6 (the symbol used for magnitudes 5 and 6 is the same). The distribution of radio sources — "stars" if you like, since we are looking at the sky now with radio eyes — is very different from the optical sky.

Most of the bright radio sources lie in the Milky Way band, and most of the weaker sources lie over the rest of the sky. This is because the brighter sources are the nearby emission nebulae and supernova remnants in our galaxy, while the fainter sources are the distant galaxies and quasars. With the unaided eye we can see only one galaxy (in Andromeda) and no quasars, so the real visible sky bears no resemblance to the radio sky. In addition, normal stars do not emit significant amounts of radio emission, so none of the familiar stars in our sky are recognizable in the radio sky. The only "star" visible to the naked eye which is also seen in the radio sky shown in our diagram is the Orion nebula.

The great differences between the sky in "radio eyes" and our real sky are due to both the different emission processes involved in generating light and radio waves, and the fact that many of the distant emission nebulae that might just have been visible to our eyes are obscured by interstellar dust.

The faintest radio sources so far catalogued would have a magnitude of about 13 on our scale. This compares with the optical astronomers' magnitude limits of 22. Part of the reason for this is that not many radio telescope systems are capable of detecting sources much weaker than that, owing to receiver sensitivity and telescope size limitations.

Strictly speaking, our magnitude scale used here is not comparable to the optical system at all since the optical magnitudes refer to the total visible light received on Earth, while we have only talked about one radio wavelength here. If we were to make a map at a different wavelength, the sky would look different — not only as far as the Milky Way is concerned, but also in the way the relative brightnesses of the weak radio sources change. We would therefore find different "constellations" at different wavelengths.

In order to make a better comparison with the optical magnitudes we would have to know how the radio source intensities varied over all radio wavelengths, know their radio spectrum, and then integrate this to get a single number referring to the total luminosity of the sources. No one has yet done this for more than a few radio sources and certainly no one has attempted this work to make a map of the radio sky showing true luminosity of say, a thousand sources. It's a gigantic task for anyone who wants to try.

There is one last fascinating difference between the radio sky at any given wavelength and the sky we actually see, and that is the presence of the variable sources. Some galaxies and quasars occasionally undergo enormous explosions which increase the brightness of the object tenfold or more. We could expect to "see" some radio sources actually flashing every few years!

Dr. Verschuur is a regular contributor to ASTRONOMY. He is director of the Fiske Planetarium and a professor in the department of astrogeophysics, both at the University of Colorado in Boulder. In addition to over 50 published scientific articles, he has contributed "The Interstellar Medium" to the 1973-74 edition of **Encyclopaedia Brittanica** *and is author of* **The Invisible Universe** *(Springer-Verlag, New York, 1974), a layman's introduction to radio astronomy.*

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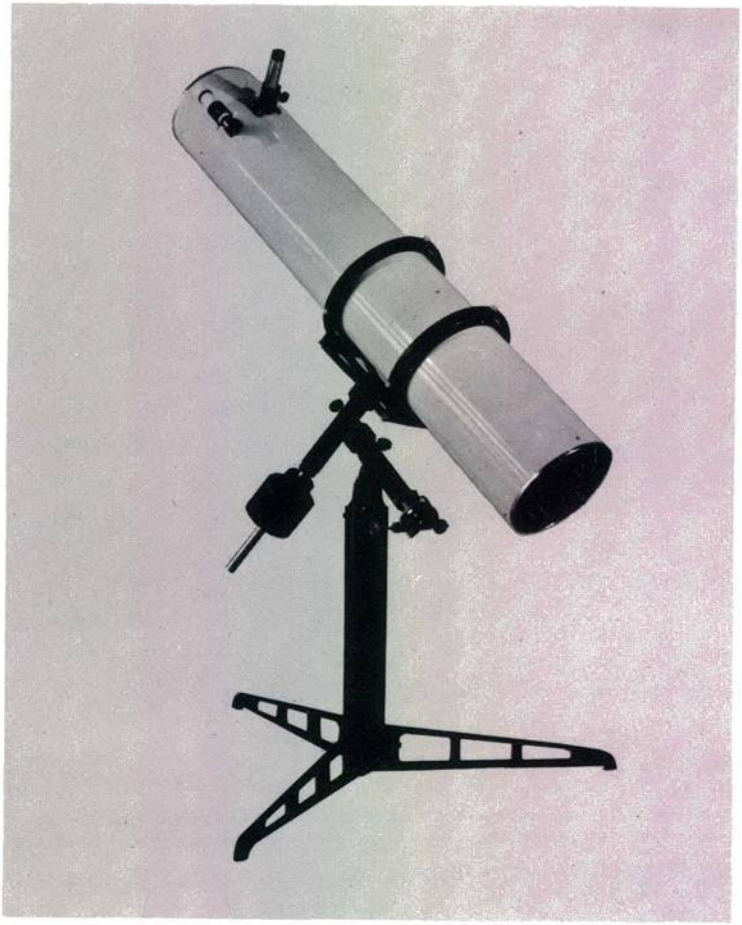

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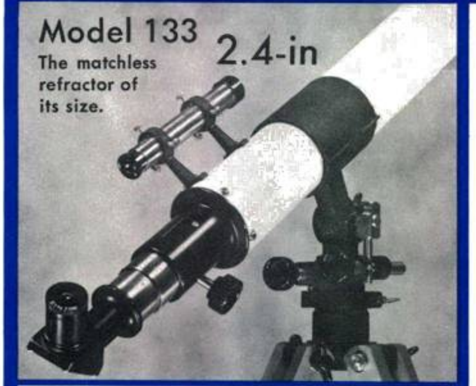

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PUBLISHER'S MEMO

The short term history of a new magazine is often measured with unsure, faltering steps. This fortunately has not been the case with ASTRONOMY magazine. Following a course which seemed clear from the start and grew clearer with each issue. ASTRONOMY bypassed most of the pitfalls into which other new magazines inevitably tend to fall.

Witness, for example, our first issue 12 months ago. In comparison with this, the July issue, our Aug. 1973 magazine was small (48 pages) and in retrospect, only a shadow of what it was to become. In spite of this, our charter subscribers saw hope for the future and stayed with us.

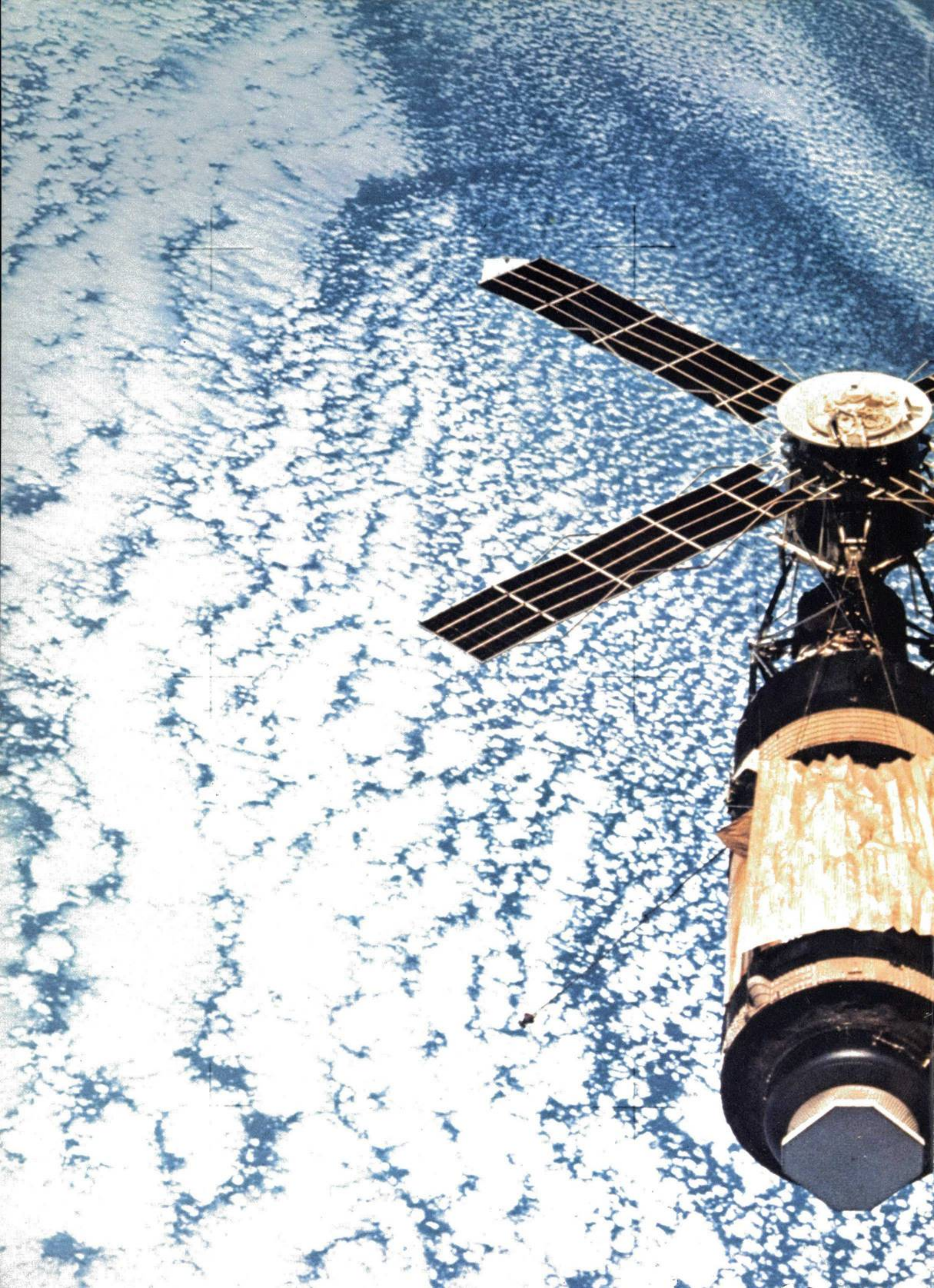
The November issue marked our first major milestone with 16 more pages, creating a 64 page format that became the model for our next eight issues. This expanded format with the addition of Astro-News and Astro-Mart beautifully and quickly evolved with the enthusiastic suggestions of our readers.

Today, ASTRONOMY is on the brink of its second year of publication. Promise and hope are stronger than ever, as your July issue reflects what ASTRONOMY may be in its second year. True, this 80 page July issue is a surprise to you. And next month we will return to 64 pages. But in the months ahead as we approach a paid circulation of 40,000, we will occasionally offer an 80 page issue until ASTRONOMY is able to retain a base size of 80 pages with Equipment Atlas and our new Astronomy Reviews section appearing each month.

Sincerely,

Stephen A. Walther

Stephen A. Walther
Publisher



Some Elements of Astrophotography

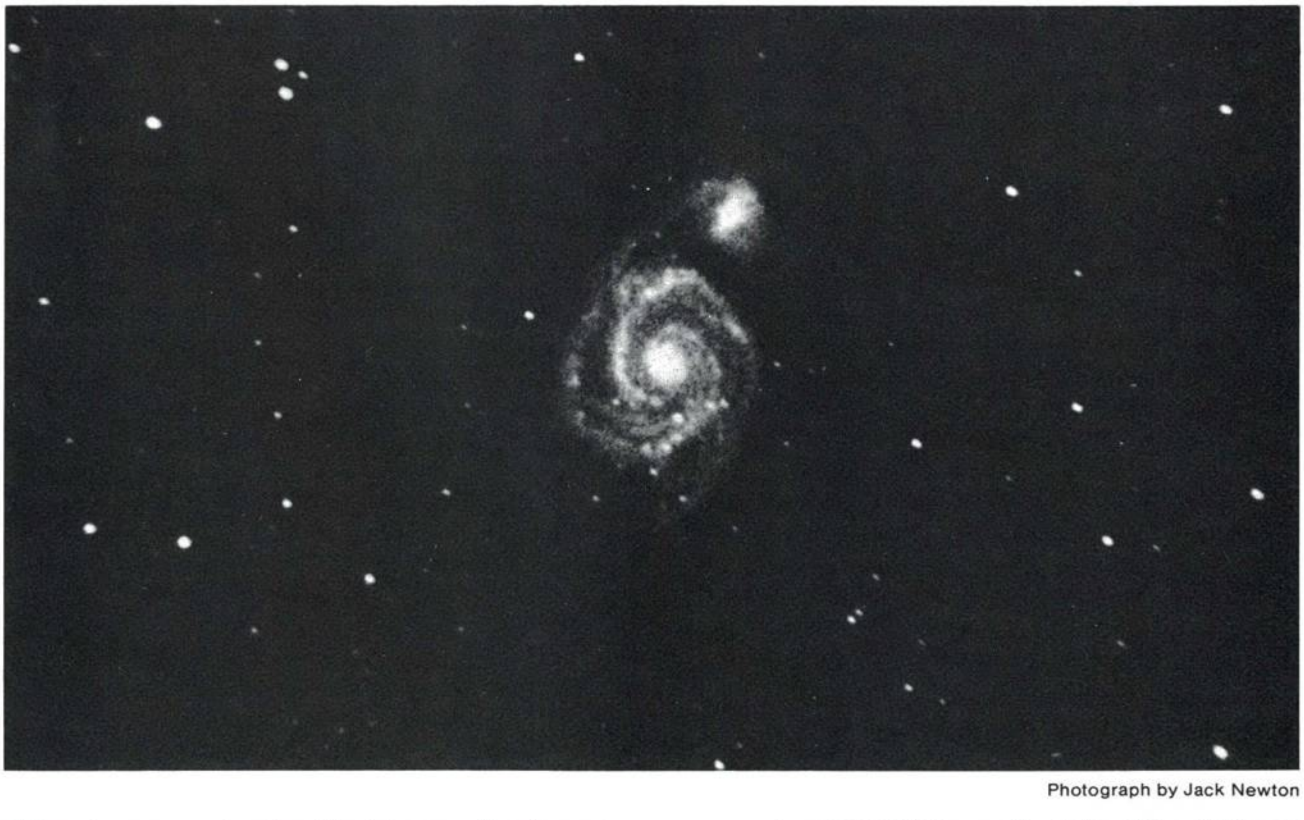
by

Jack Newton

The hobby of astrophotography has blossomed in the past few years. Single lens reflex cameras, fast film and well built commercially available telescopes have brought astrophotography out of the professional observatory and into the hands of many astronomy enthusiasts. For the photos on these pages, many camera/lens combinations were used — from the simple camera and tripod to a guided 12-1/2 inch telescope. Each serves a useful purpose.

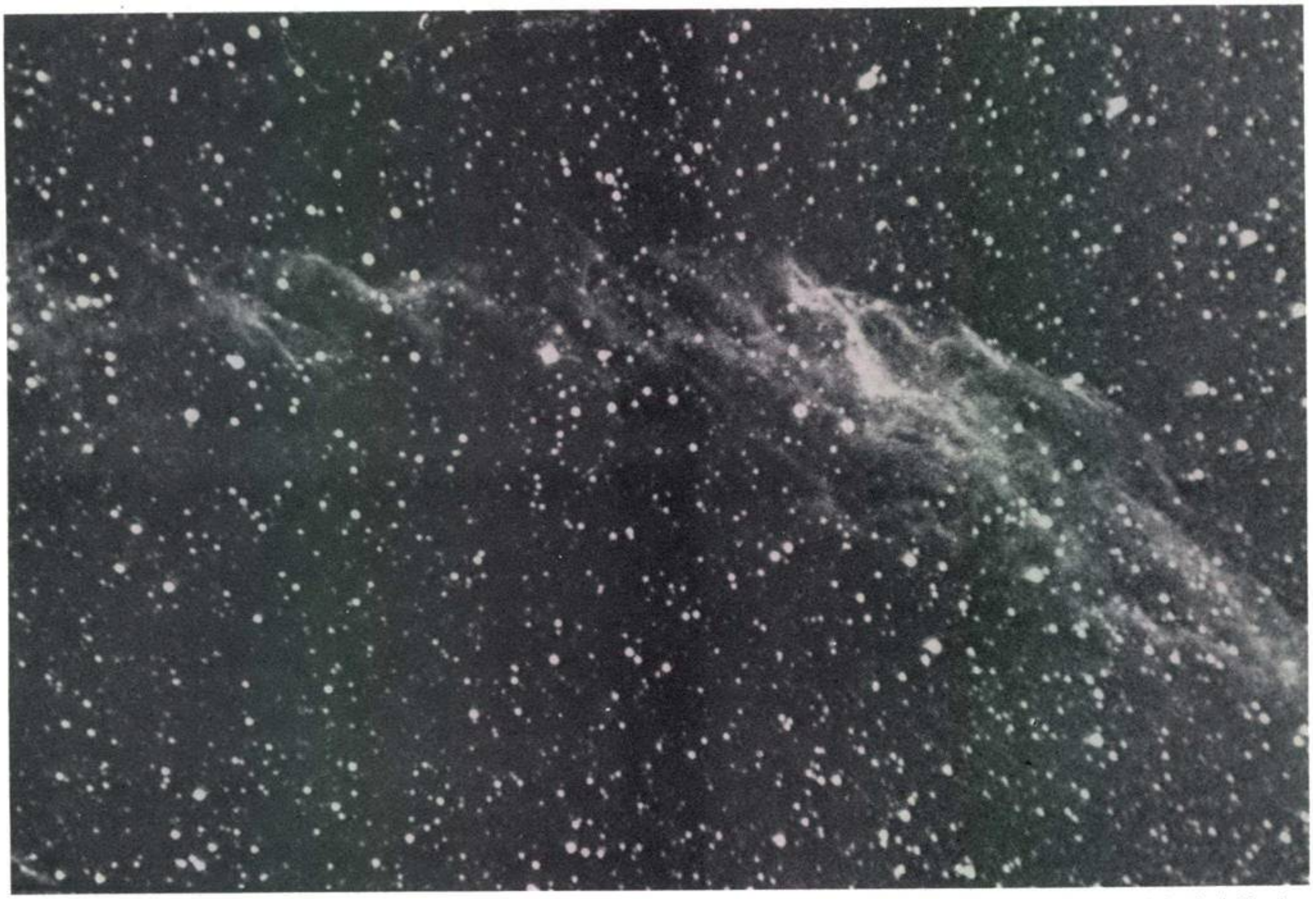
Let's start with an ordinary camera focused at infinity, and a setting that allows the shutter to remain open. Using fast film like Tri-X (black and white), High Speed Ektachrome or GAF 500 (color) you can take a wide range of exposures if the sky is moonless.

For best results set your lens wide open (lowest "f" number) and select the area of the sky or con-



Photograph by Jack Newton

Although an unspectacular object in a small telescope, M-51, the Whirlpool galaxy, can be a rewarding object for the diligent astrophotographer. This galaxy and its attached companion (NGC-5195) are about 10 million light-years away. This 20 minute exposure on Kodak 103aF film was taken through a 12-1/2 inch f/4.3 reflector.



Photograph by Jack Newton

Virtually impossible to see in small telescopes, the Veil nebula is a striking object in long exposure photographs. This 20 minute exposure through a 12-1/2 inch reflector on Kodak 103aF film shows the intricate lacing of this interstellar gas cloud that is believed to be a supernova remnant in the constellation Cygnus.

stellation you wish to photograph. Rigidly support your camera on a tripod or firm table and start with a 10 second exposure. Then add 20 seconds to each subsequent exposure up to a three minute maximum. By shooting a range you will find one combination that best suits your sky conditions and the object you want to capture on film. With this simple method you can photograph constellations, the Milky Way, satellites, northern lights, meteors, comets and many other celestial objects. Naturally Earth's rotation will cause any object to "trail" on exposures over 10 seconds.

However, if you own a telescope you can mount your camera piggyback and use the telescope to track the stars. This method allows you to utilize your camera and regular lens to take a long exposure without star trails. To do this, center a bright star in the field of a high power eyepiece. Then throw the star image out of focus until it almost fills the eyepiece. To track, merely keep the star within the boundaries of the eyepiece by manually guiding the telescope. No clock drive is required but an equatorially mounted telescope with slow motion controls is a necessity. A little practice will help you track with ease for more than 10 minutes using this method. All that's required is patience and a steady hand.

An easy way to mount your camera piggyback on a refracting telescope is by drilling a 1/4 inch hole in the dew cap approximately 1/2 inch out from the objective lens. A 1/4 inch bolt, 3/8 of an inch long, will screw into the tripod mount on the bottom of your camera. For a reflector, merely drill the hole near the top of the telescope tube. If this is not practical, the base of a flash bar can be taped to the telescope barrel and your camera mounted to that.

Up until now we have talked only about time exposures using a regular 50mm camera lens. An equatorially mounted telescope with clock drive, aligned properly on the polestar, can drive a 450mm telephoto lens accurately for over 5 minutes and a 135mm telephoto for over 10 minutes, with no adjustments required. For longer exposures, guide using minimum telescope power equal to 1/5 the telephoto's focal length in millimeters. Useful accessories include illuminated crosshairs in the guide scope eyepiece for ease of tracking; a variable frequency control for the polar axis drive, and a reversible motor for declination adjustment. Hand held controls add to the ease of operation.

It's a good idea to test the alignment of your equatorial mount before photography begins. Watch to see if your proposed guide star drifts up or down. This indicates that a declination adjustment is required. Experience is really the only guide here.

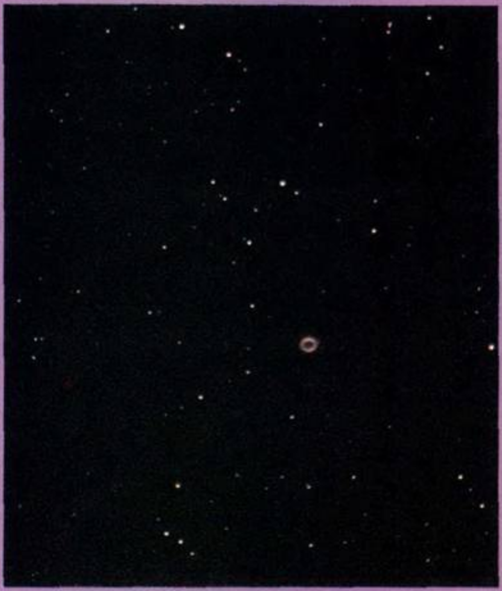
Testing various exposures up to a half hour or more will define the point at which the background sky light starts to wash out the faint nebulosity of the object being photographed.

Photographing through the telescope using eyepieces and high magnification is best accomplished with a clock driven equatorial mount.

There are several methods of adapting the camera directly to the telescope's drawtube near the point of focus. A 1-1/4 inch diameter sink extension pipe purchased from a hardware store is an inexpensive (about $1) adapter when cut to about five inches in length. You can have an adapter machined that will press over the sink extension to thread into the camera with the lens removed. It can also be made from an adapter ring which saves cutting the threads (see diagrams). The adapter can be used with eyepieces and extension ring or for prime focus photography. (Prime focus photography is merely converting your telescope into a large telephoto lens by removing the camera lens and using no eyepiece in front of the camera.) This type of adapter is by far the best. You can use any combination of eyepiece projection for any size image desired.

Direct photography through the telescope may seem easy but be careful! Even a whisper of wind will cause vibration, as will your cable release and shutter. The wind can't be controlled without shelter like an observatory, but you can do something about the cable release. A black cloth or hat held over the end of the telescope does the job nicely. You merely lock the shutter open with the cable release, and then gently lift the hat away from the telescope still cutting off the light. When all the vibration has stopped, remove the hat to expose the film. "Rehat" the telescope and release the cable to end the exposure.

As discussed in this department in previous issues, different films do different jobs. Tri-X pushed to ASA 1200 in Acufine developer is excellent for long focus refractors. The quarter moon at 50 power and 1/60 second exposure is perfect at ASA 1200 while Saturn's rings at 300 power require a 12 second exposure. Jupiter can be photographed in the same way. A one second exposure will record the belt, Red Spot or a satellite shadow.



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Some showpieces of the sky in color. (A) The tiny doughnut of gas that forms the Ring Nebula in Lyra appears red on film but pale blue to the eye. This 15 minute exposure on GAF-200 film was taken through a 12-1/2 inch f/5.2 reflector. (B) This photo of the globular cluster M-13 in Hercules bears remarkable resemblance to its visual appearance in medium sized telescopes. GAF-500 film was used for this 20 minute exposure through the same telescope as above. (C) The Great Orion Nebula, always the favorite target for astrophotographers, is seen in a 35 minute exposure on GAF-500 film. A 12-1/2 inch f/4.3 Newtonian reflector was used. (D) The rainbow shades of the Aurora Borealis was captured in an exposure on High Speed Ektachrome film. The shutter of a tripod mounted camera with a 50mm f/1.8 lens was left open for three minutes.

Photographs by Jack Newton

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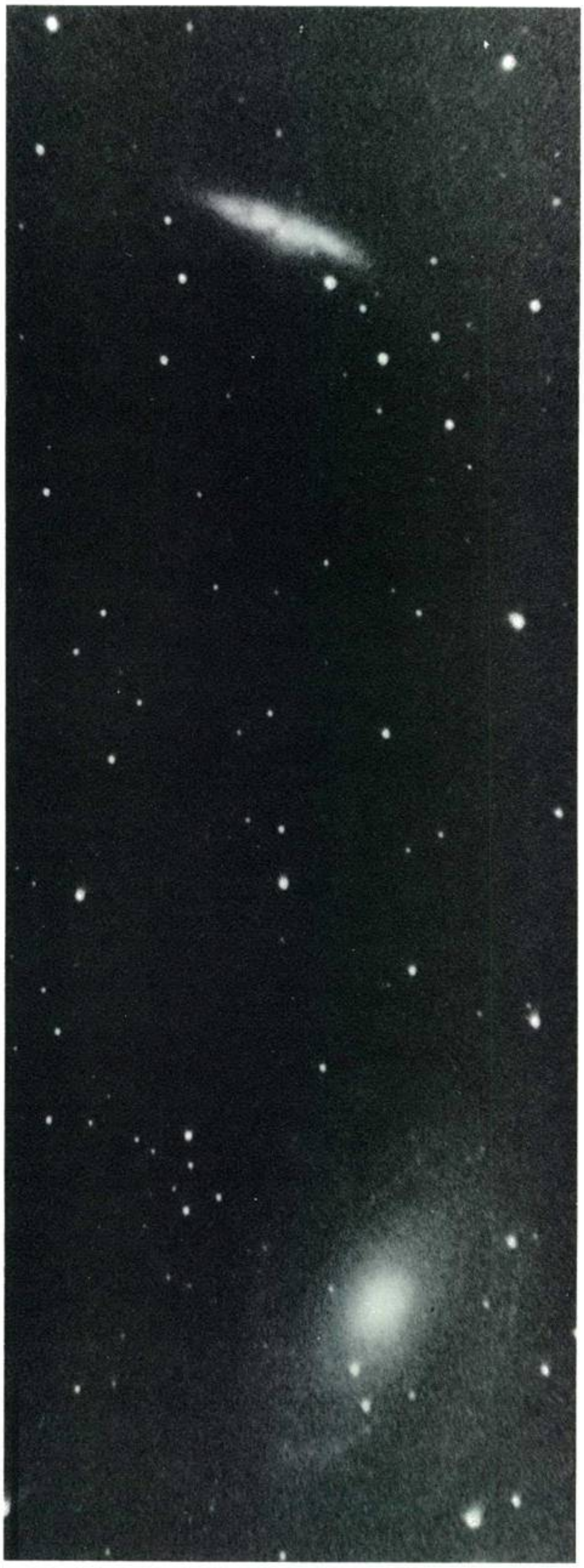


Photograph by Jack Newton

Two galaxies are captured in this 15 minute Tri-X photo through a 12-1/2 inch reflector. Near the top is M-82, a galaxy that suffered a violent eruption at its core some two million years ago. Bottom is the near normal spiral galaxy M-81, with its twirling arms faintly visible.

To record the four satellites, however, requires a 12 second exposure using 100 power. Remember, film is cheap so take many photographs varying exposures and refocusing often. Planetary photography with a six inch or larger reflecting telescope is accomplished the same way, although slower film can be used.

If you happen to own a single lens reflex camera with a mirror that locks up, you can easily take a full range of exposures without any noticeable vibration. Most single lens reflex cameras without the lockup feature will shake when the shutter is released due to the action of the mirror. This is usually only a problem for exposures under one second. The Ricoh single lens reflex camera, however, has a tremendous advantage over conventional cameras. When you use the self timer, the mirror locks up at the initiation of the timing mechanism and all the vibrations from the mirror die down during the delay. Then the shutter silently opens exposing the film. In addition, when you lock the cable release, the self timer is activated allowing you time to return to your guide scope. This gives you enough time to recenter your guide star (if needed) before the camera shutter opens starting your exposure. It is easy to see the many advantages of this type of camera.

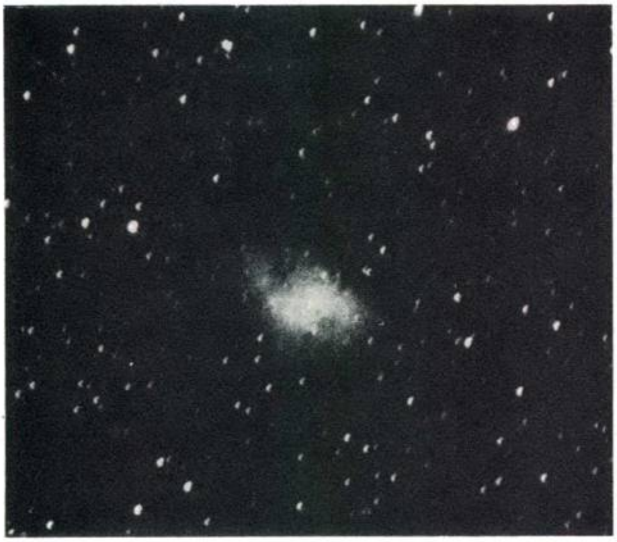
Filters are very helpful in black and white astrophotography. A light yellow filter substantially reduces background sky light, which tends to fog the film. A red filter used in conjunction with Kodak Tri-X or 103aF spectroscopic film eliminates almost all sky fog even in the heart of a city. The Horsehead nebula (IC-434) was photographed with a 12-1/2 inch telescope while cars drove by only 40 feet away. Using a wratten #25 deep red filter with 103aF spectroscopic film in a 20 minute exposure, the negative showed no trace of sky fog. Filters can be adapted to any camera combination.

Many large telescopes have been rendered useless for astrophotography because of a shaky mount. You cannot underemphasize the importance of a solid base or steady tripod.

In the darkroom Tri-X and Acufine developer give excellent results up to ASA 1200. A custom photo lab will push your film to a higher ASA on special request. When you take long time exposures, in excess of 30 minutes, slower film such as Plus-X (black and white) and GAF 200 (color) are actually faster than Tri-X at ASA 400 and GAF 500. Grain in the slower film is also more acceptable.

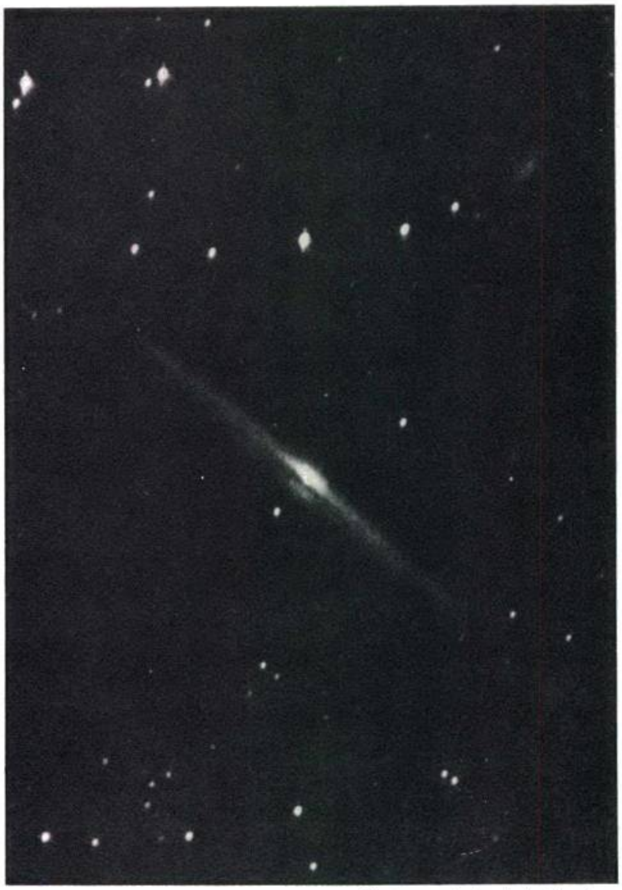
For making positives from deep sky negatives and for photographing bright planets and the moon use Kodak fine grain positive film. At ASA 5, this film has no apparent grain. Using prime focus with a 12-1/2 inch reflector, good images of the quarter moon can be obtained at 1/60 of a second exposure. Kodak fine grain positive film is monochromatic and may be processed visually in Dektol developer using a yellow safe light. The best part of it is, if you bulk roll this film (the price is about $5 for a 100 foot spool) it only costs about 15¢ a roll.

There are many darkroom tricks to enhance your final prints. Ilford #5 printing paper was used for most of the enlargements on these pages. Use a whole range of exposures when printing. Most often you will find that each of your prints will show varying detail throughout the whole range of exposures. This is caused by the fact that deep sky objects are usually of uneven intensity. M-42 and M-43 in the constellation Orion are excellent examples. When printing, underexposure shows faint outer nebulosity while overexposing shows the rich central nebulosity of the Trapezium. The darkroom trick here is to print one photograph which exhibits all of these qualities. This is partially accomplished by making a simple dodging mask. An 8 x 10 inch piece of opaque paper does nicely. Cut a 1/2 inch hole in the middle of the paper leaving rough edges. Expose the whole print long enough to bring out the faint outer nebulosity; then cover the paper with the dodging mask. By adjusting the height and circular movement of the dodging mask the hole acts like a spotlight and can be maneuvered over the central area requiring a longer exposure. After a little practice you will find the dodging mask becomes an intricate part of your printing procedure.



Photograph by Jack Newton

The Crab nebula is notoriously difficult to photograph. This 20 minute exposure on Kodak 103aF emulsion was taken through a 12-1/2 inch reflector in Feb. 1974.



Photograph by Jack Newton

This photo of the 10.5 magnitude edge-on galaxy NGC-4565 is a fine example of care and patience in astrophotography. Visually the galaxy is nothing more than a needle of light even in large telescopes. But this 15 minute exposure on Tri-X film with a 12-1/2 inch reflector shows the brilliant globe of stars in the galaxy's core as well as the faint, dust riddled arms.

Many other objects can be enhanced by dodging; the quarter moon is a prime example. A ruler fanned over the terminator during printing keeps the fine craters from being overexposed but allows the dark seas to "come up" resulting in a well balanced print. Learning other darkroom techniques will aid you in getting the best possible print from your negatives. Two common methods are highlight masking (a sophisticated step up from dodging) and integration printing (a technique where several negatives of the same object are "sandwich" printed).

For further details, see "Integration Printing: An Aid to Long Exposure Astrophotography", ASTRONOMY, October 1973; and "Highlight Masking: A Method of Detail Enhancement", ASTRONOMY, December 1973.

Jack Newton conducts his celestial photography from near his home in Newmarket, Ontario, Canada. He is one of Canada's foremost amateur astronomers.

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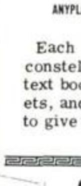

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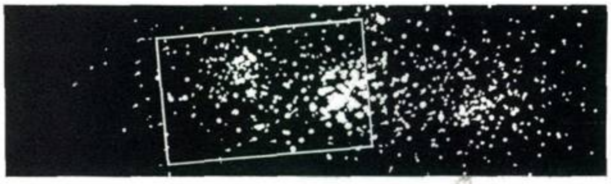

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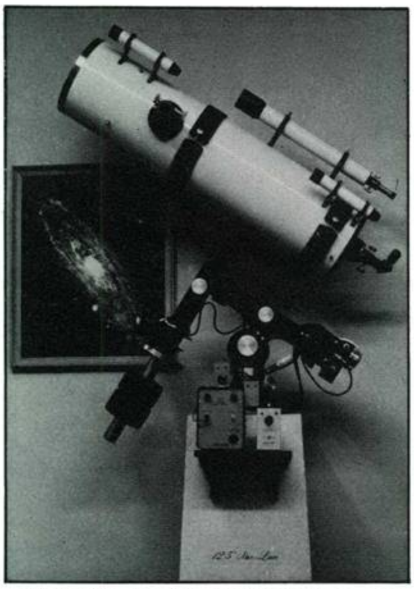

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WANTED — Persons in rural Rochester area to form an astronomy club. Interested in reports of UFO sightings. Also seeking information on college astronomy courses and astronomy careers. Write Brian Wright, 354 Taylor Rd., Honeoye Falls, NY 14472.

WANTED — Old books such as "Telescopes and Accessories" by Baker and Dimitrof, and "History of the Telescope" by King. Also need 10" mirror blank, worked or not. Write Alan P. Witzgall, 7007 Jackson St., Guttenberg, NJ 07093.

WANTED — Scripts and recordings of planetarium programs. Also information on construction of planetarium special effects projectors and recordings of strange, eerie music and sound effects. For personal interest only. Write John Stoke, 51 Headley Pl., Maplewood, NJ 07040.

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ANNOUNCEMENT –

Oct. 1973 issue of ASTRONOMY is completely sold out; certain other issues are in short supply. While they last, back issues are available for the cover price of $1.50 each (price includes postage). When ordering, state which issues you want (first issue was Aug. 1973) and include payment with request. Back issue orders cannot be billed.

WANTED — Comments, criticisms and recommendations from owners of Cave telescopes as to performance as both visual and photographic equipment. Write Wayne Downs, 4303 Harvard, Midland, TX 79701.

WANTED — Persons living in Baltimore/Washington area who are interested in forming an astronomy club. Contact Gary Liberatore, 5602 Tramore Rd., Baltimore, MD 21214. Phone (301) 426-8907.

WANTED — 3" telescope with equatorial mount. Must be in good shape; will pay up to $40.00. Write Matthew Lenoe, 15 Morton St., Andover, MA 01810.

WANTED — Star atlas and lunar atlas (preferably with space side features of the moon). Books can be in second-rate condition. Write John P. Corkill, 5301 Carriage Ln., Corpus Christi, TX 78415.

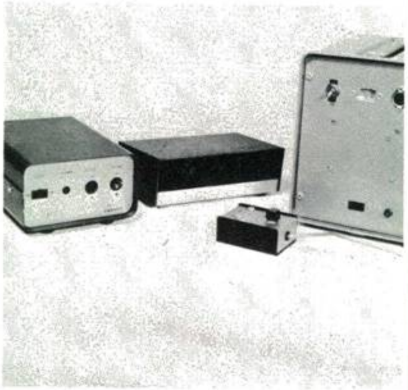
WANTED — Color and black and white photos of sky objects for publication in ASTRONOMY. Payment upon publication is $10.00 for color and $7.50 for B & W plus credit line. Higher payment for outstanding color photos. Send B & W prints or duplicate color transparencies. Do not send original negatives; we will request originals if needed. Send to The Editors, ASTRONOMY, 757 N. Broadway, Suite 204, Milwaukee, WI 53202.

WANTED — Comments, recommendations and criticisms from owners on the performance of the Dynamax 8 and/or the Celestron 8. Write John McCanne, 4106 Wayside Dr., Bartlesville, OK 74003.

WANTED — Variable speed control with push button control for astrophotography using 12 volt DC or 110 volt AC. Write or call (after 5 p.m.) Charles S. Thaeler III, 2015 Huntington, Las Cruces, NM 88001. Phone (505) 524-0332.

WANTED — 8" reflector with equatorial mount, electric clock drive, eyepieces and setting circles. Must be in good condition. Reasonable. Contact Garth White, 291 Galvan Pl., Bergenfield, NJ 07621. Phone (201) 384-4118.

WANTED — Records of rise and fall of sunspots. (Cycles average approximately 11-1/2 years each.) Would like records from 1938 to present. Please state cost. Write Albert G. Street, 2559 Diamond St., San Francisco, CA 94131.



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WANTED — Information or plans on building observatory for 6" reflector. Also information on where to purchase camera adapter for prime focus photography with a Kowa SETR 35mm camera. Write Thomas J. Gonya, 92 River St., Keene, NH 03431.

WANTED — Information on construction of amateur radio telescopes. Especially interested in designs for use in high noise areas. To be used as undergraduate research project at urban university. Write Richard J. Archer, 12035 S.W. Edgewood St., Portland, OR 97225.

INFORMATION WANTED — Wish contact with someone who might be able to give me some information about my late father, John E. Mellish. In early 1900s he worked at Yerkes Observatory and Harold's and discovered some comets. Write Patricia Roberts, Star Route, Somerset, CA 95684.

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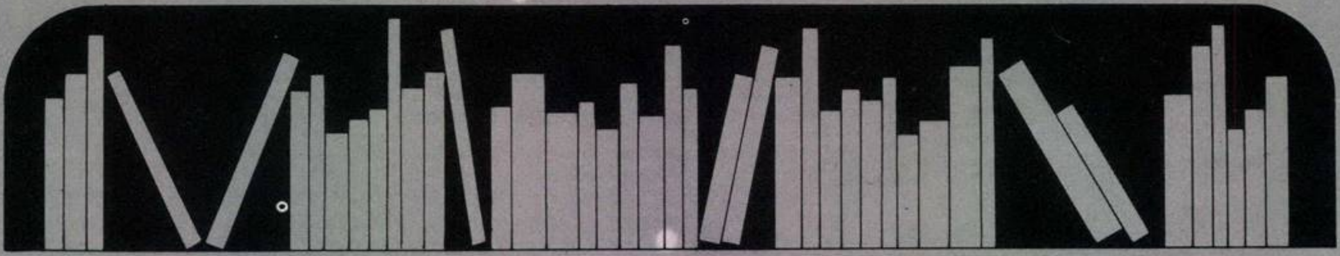


ASTRONOMY REVIEWS

From the Black Hole to the Infinite Universe

by DONALD GOLDSMITH and DONALD LEVY

330 pages, paperback, $6.95
Holden Day, Inc. (1974)

Did you ever take an astronomy course at college? Remember the textbook — full of language so stilted that it even made the possibility of life on Mars sound dull? Even today, many texts and some general astronomy books are written and illustrated as if we all were still in the 1930s studying an obscure science.

From the Black Hole to the Infinite Universe is different — much different. There has never before been an astronomy textbook like it. It is alive, dynamic, and above all, interesting. You actually want to read it — not because you have to, but because you want to!

How did Goldsmith and Levy do it?

They are obviously good teachers. They do in their book what the dynamic professor does in the lecture room: (a) start with the most exciting part of the subject first; (b) explain difficult concepts in easy-to-understand language, and (c) challenge the student with new ideas or new ways of looking at old ideas.

The authors do all this and more. For the first time in textbook history they have introduced science fiction as a key element in presenting astronomy. Each chapter is divided into three clearly marked sections: science fiction, science fact, and background theory.

The science fiction sections all link together to form one complete short story about the exploits of Captain Zaki and his crew on the starship "Top Dog". The characterizations are cleverly handled. Example: After they drop a probe into a black hole a crew member remarks "Out of sight!" Later they get drugged in the wild city of Ripov on an "uninsured" planet. During a holographic recording of a lecture, a renegade scientist says, "The Trust has decided that the study of oofoes is a bad risk." This poke at certain establishment scientists is part of the completely new approach of this book.

In the expository section, the authors wisely start with black holes, "undoubtedly the hottest topic in astronomy" said Goldsmith in a recent interview. (This section ties into the black hole probe mentioned earlier.) In a hilarious lead-in to another section, the authors say it would be easy to find out about elementary particles if we could only "grab a proton by its lapels and shake it until it revealed the information we wanted" like Sam Spade in **The Maltese Falcon**.

Avoiding even a single photograph of an astronomical object (presumably because they can be found in virtually every other textbook) the authors pepper the text with cartoon diagrams and imaginative line drawings.

So it's easy to see that this new book is far more than a textbook. It combines solid science in easy-to-understand doses with imaginative science fiction. Besides being an excellent text for senior high and one semester college astronomy courses, it is an ideal source for beginning astronomy enthusiasts interested in exploring the principal elements of the subject.

◆

Planetfall

by MARTIN CAIDIN

250 pages, hardcover, $7.95
Coward, McCann and Geoghegan (1974)

The exploration of the solar system by remote controlled space vehicles has gotten into high gear. New data on the moon, Mars, Venus, Mercury, Jupiter, comets and beyond is pouring in from trail blazing space vehicles.

Public interest in these developments is also high. Moon walks may be part of ordinary life, but rockets aimed at Saturn are still enough to excite a world accustomed to space spectaculars.

Martin Caidin, the talented and prolific aerospace writer (more than 80 works since 1957) has attempted to take advantage of this widespread interest with his latest book. By title, jacket description and publicity announcements, a reader will assume that the book will describe to him all the latest interplanetary discoveries.

If there were a "truth in packaging" law about printed matter, however, this book would be in trouble; you certainly can't judge this one by its cover.

Inside, an eager reader will find chapter after chapter of Caidin's entertaining prose describing Caidin's views on space exploration, Caidin's funny experiences at Cape Canaveral in 1960, and Caidin's own design for an interplanetary spaceship of the 1990s. Then, toward the end of the book, one finds mention of Venus, Mars and other planets.

The publisher's motives become clear. The book went to print last fall, even before the launching of Mariner 10 to Mercury, the mission of Skylab to study Kohoutek, and the arrival of Pioneer 10 at Jupiter. Anticipating these successes, and working under the long lead time associated with book publishing, someone decided that such a book, written then, would be of great demand by readers now.

And so it may be, if you want some historical background. You can read what we knew about Jupiter and Mercury before we got good data from the first space probes. You can find out all we knew about Mars before the Russian probes measured the atmosphere, all we knew about Venus before the first breathtaking photographs revealed the dynamics of the cloud cover, or all we knew about comets before Skylab examined them from space. Besides these things, you can find some good passages about the past, present and future of space exploration.

But the book does not describe the **Planetfalls** of the last year. The results of these latest breakthroughs in experimental astronomy and comparative planetology will come out month by month throughout 1974, and may wind up in a good book sometime in 1975. This is not that book.

◆

The Russian Space Bluff
by LEONID VLADIMIROV

190 pages, hardcover, $5.95
Dial Press (1973)

Ten years ago when Wernher von Braun was asked just what he expected Apollo to find on the moon, he replied laconicly, "Russians." It was not a flippant answer. Russian cosmonauts were themselves saying things like, "I can state positively that the Soviet Union will not be beaten by the United States in the race to send a man to the moon." Considering the Soviets' heavy rockets, their pioneering moon probes and manned space flights, and their expressed determination to keep and expand their apparent superiority over the U.S., few observers doubted that the above predictions would be fulfilled.

Years later, the world has a right to ask, "Whatever happened to the unbeatable Russian space lead?" The first men to the moon were Americans, after all. So was the second ship, and the third.

Some specialists insist that the Russians were never serious about moon flights, but were "more sensibly" concentrating their efforts on orbital space stations for scientific and applied experiments. But even here, the last two years have seen a series of accidents and tragedies which have completely frustrated all Russian efforts to establish their space station. The recent dramatic American "space salvage" operation which allowed our astronauts to rescue the disabled Skylab space station and to complete their mission successfully again gives one more "first" to the American space effort. Once the Space Shuttle reusable spaceship becomes operational at the end of this decade, American dominance of space technology will be established permanently.

What did happen to this Russian space lead? Between 1957 and 1965, the Soviet Union was aggressively pursuing a policy of space advances which time after time beat the fledgling American effort to every target. Did this series of breakthroughs signify the "superiority of socialism" or the "virtuosity of Russian science and engineering"? Or did this lead simply result from a secret headstart which the Russians enjoyed over the Americans, and which was quickly dissipated as the Americans, awakened to the challenge, entered the race and soon outdistanced their competitors?

Western observers have speculated that the latter explanation is more likely. Now we have a book by a Russian defector which adds fuel to their arguments. Leonid Vladimirov was a journalist who specialized in covering Soviet space and scientific events. When he defected to Britain in 1966, he tried to convince Western specialists that the Soviet lead, which at that time was only beginning to be matched by a growing American effort, was a very fragile — even illusory — advantage.

Vladimirov insisted that the Russians were concentrating their meager resources in areas in which they knew (from reading the Western press) they had a chance to be first. Their ICBM program was started in 1946, and by 1957 had produced the booster rocket used in all their initial space successes. The same booster rocket is still, 15 years later, the mainstay of their program. The Americans, on the other hand, started later — in 1954 — and after initial successes with their Atlas and Titan ICBMs, moved on to the development of the giant Saturn rockets — rockets which the USSR has not yet been able to duplicate.

Vladimirov's book, written originally in 1967, tried to explain how the Russians could never be the first to the moon. The engineering and technology of sending spacecraft to the moon, descending to a precise and gentle landing, then blasting off and maneuvering in space, are far more complicated than the mission of putting a man in a capsule and shooting him around Earth. Vladimirov said in 1967 that the Russians were not capable of such a mission. Understandably, this thesis was looked upon with overwhelming skepticism, and no publisher would touch his book. Hadn't the Russians launched the first satellite, the first moon rocket, the first man (and later, woman) into space? How could all these brilliant achievements be regarded as "bluffs"?

A few years passed, and the Russians did not fly to the moon. Americans orbited around the moon, then landed on it, and then returned for more extensive exploration. No word came from Moscow. The climate of skepticism improved enough so that Vladimirov's book was finally published in Great Britain in 1971.

This book gave extensive evidence from personal contacts and personal recollections which indicated that the myth of Russian scientific superiority was as much a self-deception on the part of the West as it was a deliberate propaganda line from Moscow. This was not very flattering to many British scientists who had fallen for their own myth, and now felt compelled to defend it. The Russians had never intended to send men to the moon, these scientists argued. The Americans had been racing themselves while the Russians calmly and deliberately set about creating the most useful space project — near-Earth manned space stations.

But with the series of Russian space station failures since 1971, even this last-ditch argument has collapsed. It is now becoming clear that from the beginning the Soviet space program has been grossly overrated. How was such a deception possible?

Vladimirov's book probes this question at great length, and ultimately argues that it was the excessive and overwhelming system of secrecy which covers the entire world of Soviet science that allowed this "bluff" to go on. His book casts a great deal of light into corners of Soviet science that have been purposefully kept dark by Moscow news managers and propagandists.

In the end, Vladimirov concludes, it was the personal drive and ability of one man which was the prime factor allowing the Russians to accomplish even as much as they did. The Ukrainian scientist Sergei Korolyov must go down in history as the man who opened the way into space. Despite years in Stalinist slave labor camps, the later jealousy of party hacks, and his own failing health, Korolyov convinced Nikita Krushchev of the need for a strong and forward-looking Soviet space program, and then organized and carried it out almost singlehandedly.

Kruschev was overthrown in 1964, and Korolyov died 14 months later. Since that time, the Russian space program has fallen upon very hard times: dead cosmonauts, exploding rockets, disintegrating space stations, and recently three out of four failures on their ambitious Mars expeditions. Russian persistence may eventually overcome their difficulties, but the "Russian space bluff" has been permanently dispelled.

◆

Mars
By PATRICK MOORE and
CHARLES A. CROSS

48 pages, hardcover, $7.95
Crown Publishers (1973)

Remember the Mariner 9 mission to Mars? As the spacecraft orbited the red planet it sent back to Earth a wealth of photographs and other data during its lifetime (late 1971 and 1972). Some of the more spectacular pictures appeared in newspapers and magazines, including this one. But too often the results of a major space mission are reported in pieces or are confined to obtuse journals. In this single volume, however, a good portion of the results of Mariner 9 are detailed in a comprehensive and highly digestible way.

Don't be fooled by the note above indicating a length of only 48 pages. Each page is almost twice the size of the one you are reading and is crammed with information. There are nearly 100 illustrations — many in color — that are the heart of this well conceived guide to the red planet.

This is not an observer's guide to Mars. There is little about what Mars looks like through a small telescope or when to observe it. But it is not intended to be such. The aim is (primarily) to present the photographic results of Mariner 9.

With charts, photos and diagrams the authors give a clear and accurate portrayal of our new view of Mars. Cross divided the globe of Mars into six zones and prepared remarkably detailed charts that show features as small as 10 miles across. Elsewhere attention is zeroed in on interesting areas by relating individual Mariner photos to the main maps.

And there is much more. This is definitely the best up-to-date book on Mars available to the nonscientist.

The Comet Kohoutek

by JOSEPH F. GOODAVAGE

189 pages, paperback, 95¢
Pinacle Books (1973)

If you happened to buy this book last fall when Comet Kohoutek was theoretically going to be the "greatest fiery chariot of all time" (according to the author), you probably are wondering why we are reviewing it. If you did read it we want to assure you that most of the things you encountered in it were the author's opinions and not those of the majority of astronomers or the editors of this magazine. The book was put together with the sole purpose of raking in a pile of cash at the expense of those who really wanted to find out something about Comet Kohoutek and were disappointed at the lack of information available.

It's unfortunate that a bad book can be written quickly and a good book takes more time, because in the case of Kohoutek, there were about five months available to prepare a book on the comet and get it printed and distributed to the newsstands.

In the preface of this paperback, Goodavage says that his "aim was to confine this book to hard reports — real universe data that you are unlikely to find elsewhere." The reason that you are unlikely to find most of the content of this book elsewhere is that it was either dreamed up in Goodavage's head, or else exhumed from books and newspaper reports that should have remained buried in the morgues they likely came from.

Goodavage freely mixes quotes from such astronomers as Carl Sagan, Robert Richardson, Brian Marsden and Steve Maran with Emanuel Valakovsky and newspaper reporters. He relates the major eruption on the sun in Aug. 1973 to "the comet affecting not just the solar field, but the sun itself and we can anticipate world shaking, long range consequences."

Need we say more?

Patrick Moore's Color Star Atlas

by PATRICK MOORE

112 pages, hardcover, $7.95
Crown Publishers (1973)

The perfect star atlas for the beginning astronomy enthusiast has not yet been printed. But this lavishly illustrated book is perhaps the best effort yet.

Let's outline what a perfect (in our opinion) beginner's atlas should have: (a) clear and easy to read charts and diagrams; (b) finder charts to get started; (c) maps showing all naked eye stars and every object the beginner is likely to search for in his telescope, and (d) complete explanations of all terms and concepts like magnitude, right ascension and declination, Bayer and Flamsteed designations, nebula, globular cluster, etc.

Moore's atlas scores high marks in category (c) since the most detailed of the three sets of charts in the book has stars to magnitude 6.5 and shows all the notable objects. Category (a) is also fully satisfied. Unfortunately (b) and (d) are not. The use of the prime pointer in the sky, the Big Dipper, is not exploited nor are other obvious geometrical relationships of bright first and second magnitude stars. The author must assume (although he doesn't say so) that the reader is already aware of these relationships. In the case of our requirement (d), some explanations are a little brief. It is doubtful if anyone unfamiliar with the celestial coordinate system would be much more informed after reading the summary in this book. On the other hand, the section on galaxies is more than adequate.

But as we said, this is perhaps the best effort yet. The reproduction of the diagrams, charts and numerous color photos is excellent.

Besides the useful maps, there are concise descriptions of each constellation and the interesting objects therein. Dozens of color and black and white observatory photos display the celestial showpieces. Moore is careful to warn that the visual appearance is much more subdued than these photos indicate.

Patrick Moore is a British amateur astronomer who has been writing popular astronomy books for 20 years. He has definitely improved with age — some of his earlier works were certainly second-rate compared to this highly recommended reference book.

Our World in Space

by ISAAC ASIMOV with paintings by ROBERT McCALL

176 pages, hardcover, $19.95
New York Graphic Society (1974)

This huge book is a visual blockbuster. With 72 color pages of Robert McCall's imaginative, but scientifically sane paintings, this lavish volume will leave a lasting impression on anyone who sees it. It is exactly the kind of book that will rivet the attention of anyone from age 8 to 88 who has the slightest interest in the exploits of man in space.

Isaac Asimov's text is excellent, as might be expected from the world's most prolific science writer. (Asimov has authored about 150 books.) He takes us from man's first awareness of the moon and sky to the fascination and final achievement of traveling to our nearest neighbor in space. But he doesn't stop there. The last two-thirds of his lucid text catapult us to moon colonies, Mars, Jupiter and finally the stars — all in the context of manned exploration.

It's an inspiring journey, fabulously embellished by McCall's paintings (one of which appears on page 17). Only superlatives are suitable for describing this book that will be cherished by anyone who looks with anticipation toward man's future in space.

Books are expensive — especially astronomy books. Seldom is one priced under $5.00, and some cost as much as a two year subscription to this magazine. So great care should be taken to make sure you get the right book for your level of experience and sphere of interest.

That's the purpose of this department — to outline in plain language what a book is about and whether it suits your particular desires for more information. We won't hesitate to point out a book's good and bad features. We're not trying to sell books — we're trying to let you know what's available. This, then, will be a sort of consumers' guide to astronomy books.

GAZER'S GAZETTE

Observing the Crescent Moon

Almost everyone remembers their first look at the moon through a telescope — that first glance at the silvery orb with its battered, pockmarked face is a moment to remember. Your eye drinks in the seemingly three-dimensional image with stark black shadows and dazzling white rayed craters. Your gaze then moves along the rugged terminator separating the day and nighttime portions of our satellite. You pass over mile high crater walls and across rumpled plains, and finally — at the "top" and "bottom" of the moon — the rugged polar regions.

These recollections of a first look at the moon are shared by anyone who owns a telescope when the view is offered to someone who has never seen our nearest celestial neighbor with anything but his own unaided eyes. Every telescope owner must know the "oohs" and "aahs" that come unprompted from the delighted first lookers.

But then there's the other side to the telescope/moon saga, and that is the ease with which the moon can be observed. This is often the very reason why it is observed so little. It is passed by for the more exotic beauty of Saturn's rings or the festoons in Jupiter's north temperate belt. Probably certain star clusters are more frequently scanned by some astronomy enthusiasts than the pitted face of our natural satellite. So, for those who have ignored the moon during their recent evenings with head bowed at the eyepiece, let's take another look. Or if you haven't yet discovered the exquisite beauty of that world that lies only a quarter of a million miles away, now is an appropriate time.

As we learned from the Apollo missions and from studies for many decades before, the moon's surface is an unchanging vista. The craters and plains that we see are the same ones that Galileo looked at and the same ones that cavemen wondered about when they first questioned the nature of the silvery globe that rides the night sky.

In this department, over the next year or so, we will be devoting certain months to the various phases that our satellite presents to us. This month's focus is on the crescent moon — the phase that is often framed by the most lustrous of backdrops since it follows the sun fairly closely down to the western horizon. For this reason it can be beautifully enmeshed in a golden sunset.

In the deepening blue of twilight the telescope employing 40 or 50 magnifications will permit the crescent moon to neatly fit into the field of view — perfect for close examination by the eye of anyone who wants to take the time to look. On the following pages we show the crescent moon as it appears halfway between new moon and first quarter. It will be approximately this phase on the 22nd and 23rd of this month. Thereafter the phase will increase to show more of the side of the moon that faces Earth than we see here; before that date the crescent will be slimmer.

As the terminator creeps westward on the moon as it orbits around Earth, the zone to watch from night to night is the area where the shadows are longest, close to the terminator. Following this zone throughout the cycle of the lunar phases gives you two views of each feature — once at sunrise and once again at sunset.

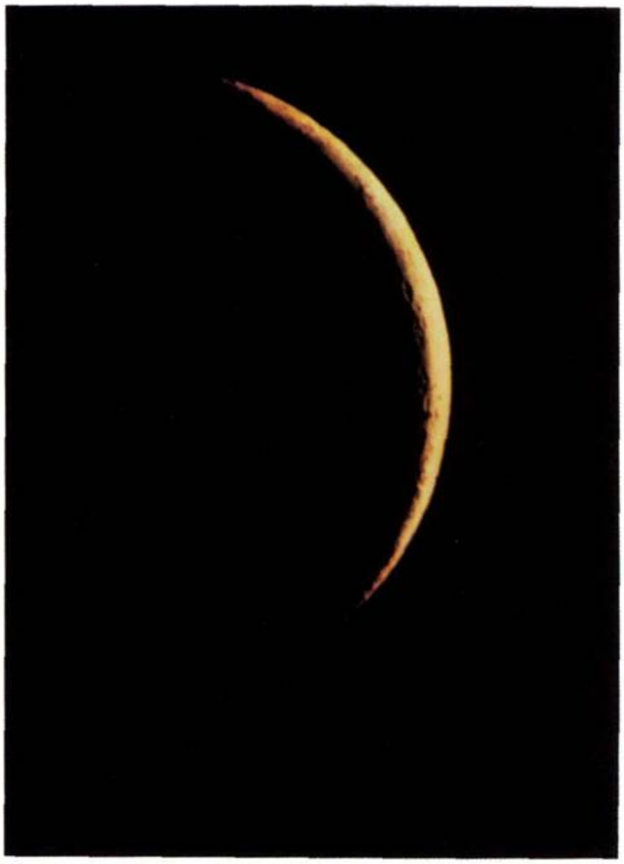
The features that are shown in the photograph and labeled in the diagram can all be seen with a 2.4 inch refractor at about 40 power. Even 10 power binoculars will show a large number of these features. This latter fact may be surprising until you actually try looking at the moon with a pair of binoculars. (Make sure they are rigidly supported either on a tripod or against a fence, or on something that will keep them from jiggling in the grip of your hands.) It's surprising how many binoculars have never been turned to the moon. They can begin a fascination that really never ends no matter how large the telescope used.

Let's now take a look at some of the specific features. There are two basic kinds of features on the moon — the familiar craters, and the plains called mare or seas. One of the darker and more prominent of the seas is Mare Crisium — the Sea of Crises. It's rather large in area and presumably was once a vast crater that became filled with lava early in the moon's history. The walls seem to have been battered down, adding to the level, plain appearance that we view today. Mare Crisium is not quite circular. Actually it's 360 miles wide and 280 miles in the north-south direction. Because of the foreshortening effect we get by looking at it at an angle, it appears almost circular. There are a number of small craters on the floor of Mare Crisium that show up rather well, especially when the terminator is passing over them.

Among the prominent craters is the giant Langrenus, seen here somewhat swamped in sunlight. It can be better viewed when the moon is a slimmer crescent, as shown in the photo on this page. Langrenus' huge walls range up to two miles above its floor and a mile above the surrounding region. This vast 85 mile wide crater has a central peak extending more than 3,000 feet above the floor. Langrenus was photographed extensively by the Apollo 8 astronauts. Because they were the first to orbit the moon in that preliminary mission of reconnaissance, the photographs were well displayed on their return. The true dimensions of Langrenus can be imagined if one thinks that the entire state of Rhode Island could be placed within its ramparts.

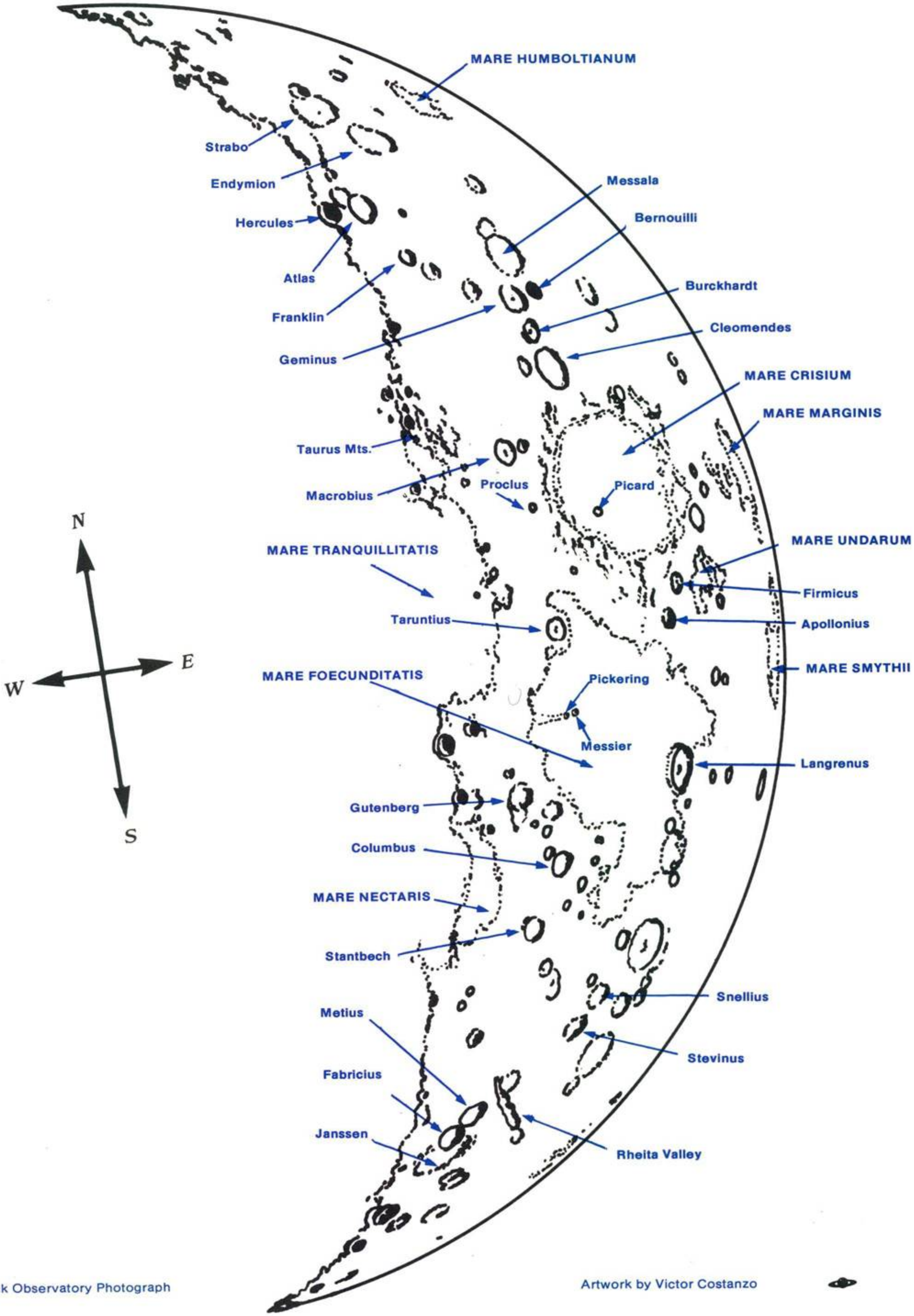
Langrenus is on the eastern side of Mare Foecunditatis, a vast plain marked by two fascinating craters (Messier and Pickering) which look upon close inspection as if they were caused by an object plunging into one of the craters, bouncing back out off a solid subsurface of the moon, and exiting through the other crater. To the south of Mare Foecunditatis is a region of interesting contrast between craters and plains. Among the more obvious craters is Stantbech, 40 miles in diameter with impressive two mile high walls. Farther south is the truly colossal crater Metius, 55 miles wide and 19,000 feet (almost four miles) deep. Metius is within a rugged zone of our satellite where craters are virtually on top of each other. The contrast between this area and the smooth mare basins to the north is part of the moon's unending fascination.

The moon is the only celestial object that looks just as beautiful through a small refractor as it does in the eyepiece of a huge observatory telescope. Most telescope eyepieces that yield powers over 75 or so have fields of view too restricted to permit viewing of the entire moon. Although higher powers on large telescopes will show more detail, it is the sight of an entire world swimming in the void that leaves a lasting impression.



Photograph by Edward C. Mayer

The 2-1/2 day old moon is a slim crescent that is difficult to observe and even harder to photograph. Langrenus and its central peak is visible along with some other major crater basins.


MARE HUMBOLTIANUM
Strabo
Endymion
Hercules
Atlas
Franklin
Geminus
Messala
Bernouilli
Burckhardt
Cleomendes
MARE CRISIUM
MARE MARGINIS
Taurus Mts.
Macrobius
Proclus
Picard
MARE TRANQUILLITATIS
MARE UNDARUM
Firmicus
Apollonius
Taruntius
MARE SMYTHII
MARE FOECUNDITATIS
Pickering
Messier
Langrenus
Gutenberg
Columbus
MARE NECTARIS
Stantbech
Snellius
Metius
Stevinus
Fabricius
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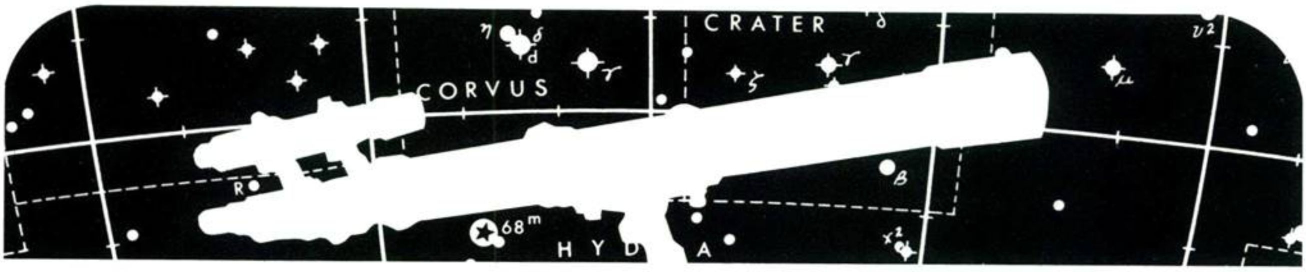
← Lick Observatory Photograph

Artwork by Victor Costanzo



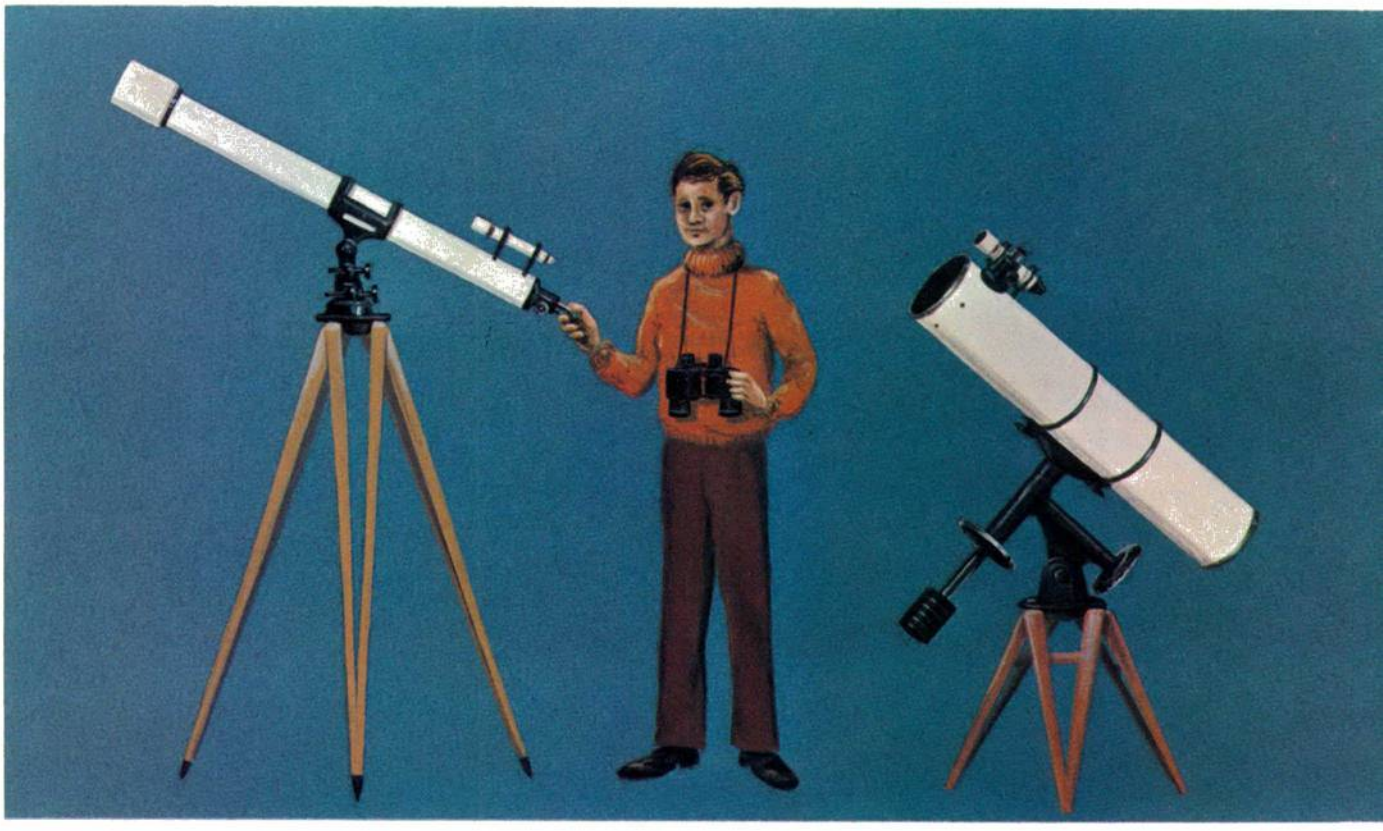
EQUIPMENT ATLAS

An Introduction to Small Telescopes

by

Alan E. Nourse

Useful as binoculars may be in locating and observing multitudes of celestial objects, any serious backyard astronomer will sooner or later want a telescope to aid him in his exploration. Many people assume that only huge observatory telescopes could possibly be effective for studying the



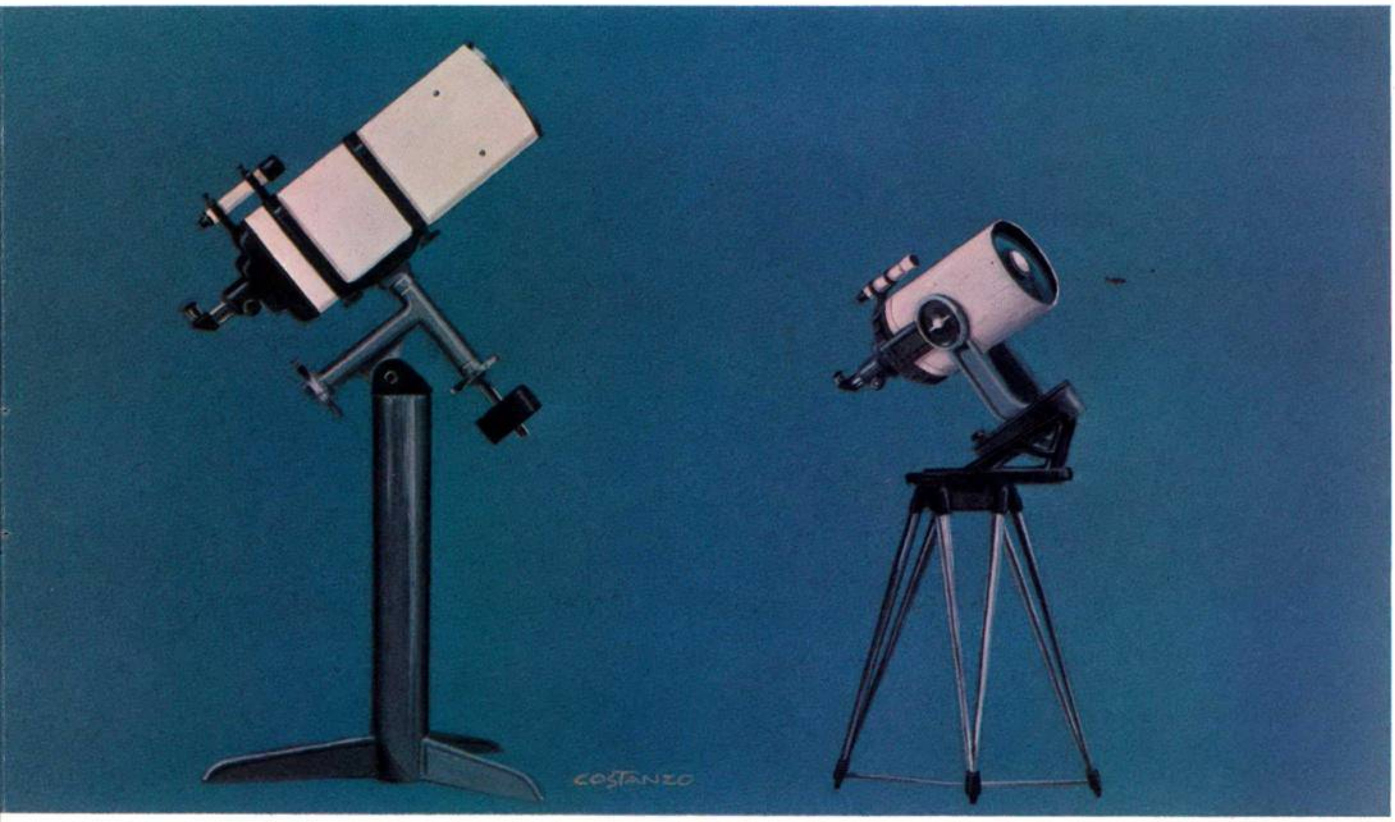
sky, and that any useful telescope must necessarily be extremely costly. Fortunately neither of these ideas is true. While professional astronomers do indeed require large telescopes and complex equipment to probe the outer limits of the universe, the astronomy enthusiast will find that a small, low priced telescope of good quality can greatly enrich exploration of the nighttime sky from the backyard.

Two different kinds of telescopes are commonly used for astronomical observation — each with certain advantages and disadvantages. Perhaps most familiar is the so-called refractor telescope, a direct descendant of the earliest telescopes invented in Holland in the early 1600s and later modified by Galileo for his stargazing. The other variety is the reflector telescope, first invented by Sir Isaac Newton in order to overcome certain of the disadvantages of refractor telescopes, and a type of instrument that is widely used by amateur astronomers today.

The earliest refractor telescope was little more than a long hollow tube with specially ground glass lenses mounted in either end. One end of the tube held a rather large objective or "light-gathering" lens, thin at the edges and bulging outward on either side in a biconvex form. The purpose of this lens was to gather light from the stars and bend the light rays so that they came to a focus at some point down the tube. The second lens, mounted in the other end of the tube near the focal point of the objective lens, was called the eyepiece or ocular lens and served simply to magnify the image at the focal point so that it appeared larger through the lens than when seen by the unaided eye.

One great advantage of any refractor telescope is that a comparatively small objective lens (no more than two or three inches in diameter) has remarkable light-gathering power, and when used

There are four basic types of telescopes in use by astronomy enthusiasts in the 1970s. They are represented here in different sizes and on different mountings for comparison. Far left is a three inch refractor on an altazimuth mount. Popular sizes for refractors are 2.4 inches to 4 inches. Next to the refractor is a six inch Newtonian reflector on a German equatorial mount. This size and mount combination is the favorite for Newtonians but they are common in sizes up to 12-1/2 inches aperture. The eyepiece position at the upper end of the tube is the distinguishing feature of these reflectors. The largest telescope shown here is the 10 inch Cassegrain reflector, also on a German equatorial. This type of reflector is a favorite for astronomy club observatories and is seldom seen in sizes under eight inches. Unlike the larger Newtonians, the eyepiece is conveniently located at the bottom of the tube. Finally (far right) an eight inch Schmidt-Cassegrain represents the most compact, most expensive and most versatile type of telescope. (A similar type is the Maksutov, not shown.) These scopes unite the best features of both refractors and reflectors into a small compact instrument. They are usually, as seen here, on fork equatorial mounts. The fork mount has the advantage of not needing heavy counterweights. These compact scopes range from lightweight three inch models to observatory sizes over 20 inches. In choosing a telescope there are many factors to consider as Nourse describes in this article.



Artwork by Victor Costanzo

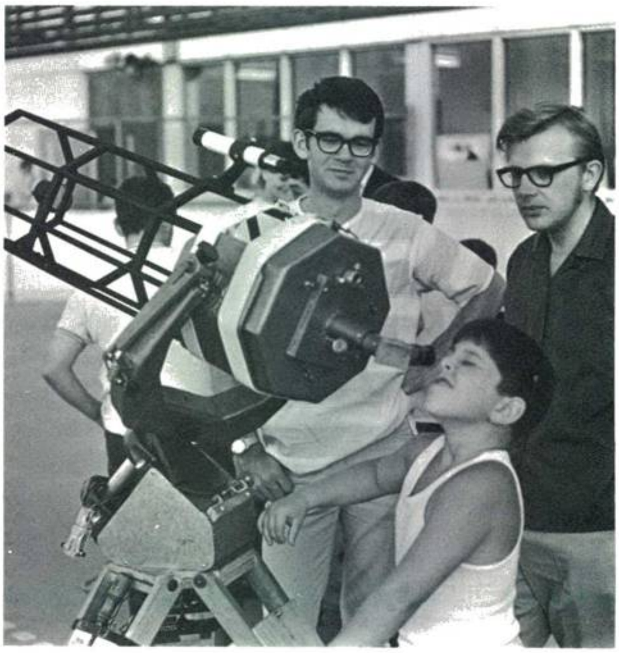
with a very small ocular lens can greatly magnify celestial objects and bring them to a clear and brilliant focus. But early astronomers soon found that refractor telescopes had certain built-in disadvantages. One serious problem was that light from celestial objects, in passing through the glass of the objective lens, tended to separate into its component colors so that the image at the focal point seemed to be surrounded by fringes of color — a condition known as chromatic aberration. In addition, because the objective lens had to be thicker at the center than at the edges, light entering the telescope through the edges of the lens tended to be bent or refracted less than that passing through thicker parts so that the part of the image at the edge of the field of vision tended to be slightly distorted or smeared — a condition known as spherical aberration.

One way to avoid these problems was to make a very large, thin objective lens that bent the light very little, so that the focal point was a long distance away from the lens. Some 17th century astronomers built refractor telescopes that were dozens or even hundreds of feet long — but these unwieldy instruments were very difficult to use. In modern times optical engineers have developed multiple lenses made of different kinds of glass to correct or counteract these problems. Modern refractor telescopes may have as many as six different components making up the objective or eyepiece lenses. But since each of the component lenses must be ground and fitted to a high degree of precision, a really good refractor telescope — even a small one — can be quite expensive.

Even disregarding expense, there is a practical limit to how big or powerful a refractor telescope can be made. The larger the telescope, the heavier and thicker the objective lens must be, and these lenses must be made from virtually flawless glass. Thus a refractor telescope with an objective lens of five or six inches is extremely expensive to construct, and telescopes with still larger objective lenses require special mounting and balancing devices to hold such a large and heavy piece of glass in place for use. The largest refractor telescope in professional use today, and probably the largest ever likely to be built, is a fine telescope at Yerkes Observatory in southern Wisconsin, with an objective lens 40 inches in diameter.

Because of the early difficulties with refractor telescopes, a totally different type of instrument, the reflector telescope, was invented. These instruments have one enormous advantage over refractor telescopes. Starlight entering the telescope is not passed through a glass objective lens at all before coming to focus at the eyepiece. Instead it is passed down a completely open-ended tube to strike a curving mirror at the bottom. The mirror's surface is carefully ground to a dish shaped curve known as a parabola. Parallel light rays striking the parabolic mirror of a reflector telescope then bounce off the mirror at such an angle that they are brought to a focus at a point above the mirror. In the most common type of reflector telescope, the Newtonian, a small flat mirror is suspended diagonally in the tube to intercept the reflected light rays just before they reach their focal point and bounce them at a 90 degree angle into a magnifying eyepiece at the side of the telescope tube.

Because the light from the stars never passes through it, the glass of the reflector's mirror need not be perfect; only the curving mirror surface must be ground and polished to precision. This means that comparatively large light-collecting mirrors can be ground at far less cost than objective lenses for refractor telescopes of comparable size. Even more important, there is no chromatic or spherical aberration of light rays, so that the reflected and focused image in the reflector telescope is free of these distortions. And while it is true that a reflecting telescope does not gather as much light as a refractor of comparable size because of the central obstructing mirror, it has proved both practical and inexpensive to make reflecting mirrors much larger than refracting lenses. Thus the largest reflector telescope in the world



This 10 inch homebuilt Cassegrain reflector is equipped with a fork mounting. With this type of mount the telescope is, in effect, attached directly to the polar axis thus eliminating the need for a "cross-axis" and counterweight. Fork mounts are set up with the rotational axis of the fork pointing to the celestial pole. The rib structure of the tube of this telescope makes it lightweight but air currents and stray light can hamper observations.

today, the Hale telescope at Mount Palomar Observatory in California, has a parabolic mirror that measures 200 inches (almost 17 feet) in diameter; a reflector telescope currently under construction in the Soviet Union will have a 236 inch reflecting mirror.

Which kind of telescope is most practical for the beginning astronomy enthusiast? There are a number of factors you will want to consider. A good refractor telescope with an objective lens between 2.4 and 3.5 inches in diameter (60 to 90mm) will provide ample light-gathering power and will yield sharp, clear images. Most modern refractors of this size are fully corrected to eliminate spherical and chromatic aberration. Such a telescope is particularly useful in studying the surface of the moon or the planets of the solar system. Anything larger would, however, be considerably more expensive than a reflector telescope of comparable mirror size. A good commercial refractor telescope with a four inch or larger objective lens not only costs several hundred dollars but might prove impractical for other reasons as well. Such telescopes are large, long and bulky, and therefore generally require a permanent mounting.

For a beginner, a modestly priced refractor telescope with an objective lens ranging from about 2-1/2 to 3-1/2 inches will serve admirably well until you become experienced enough in its use to determine what improvements you need for the kind of observing you wish to do. Such an instrument is light, compact and portable. It is easy to use, requiring no adjustment of lenses or mirrors. And because it is sealed against dust, dirt and moisture, it is easy to maintain in good working condition — requiring little more than a clean, dry place for storage and inexpensive lens caps to cover the objective and ocular lenses when the instrument is not in use. Finally, the lenses will never deteriorate if the telescope is properly cared for, so the refractor telescope will always provide a bright, clear image of the objects being viewed.

Why, then, do so many amateur astronomers own and use reflector telescopes? Not the least consideration is the matter of cost. Whereas a good refractor telescope with a 3 or 3-1/2 inch objective lens may require a basic investment of $200 or more, reflector telescopes with mirrors ranging from 4 to 6 inches in diameter may be purchased in the range of $100 to $300.

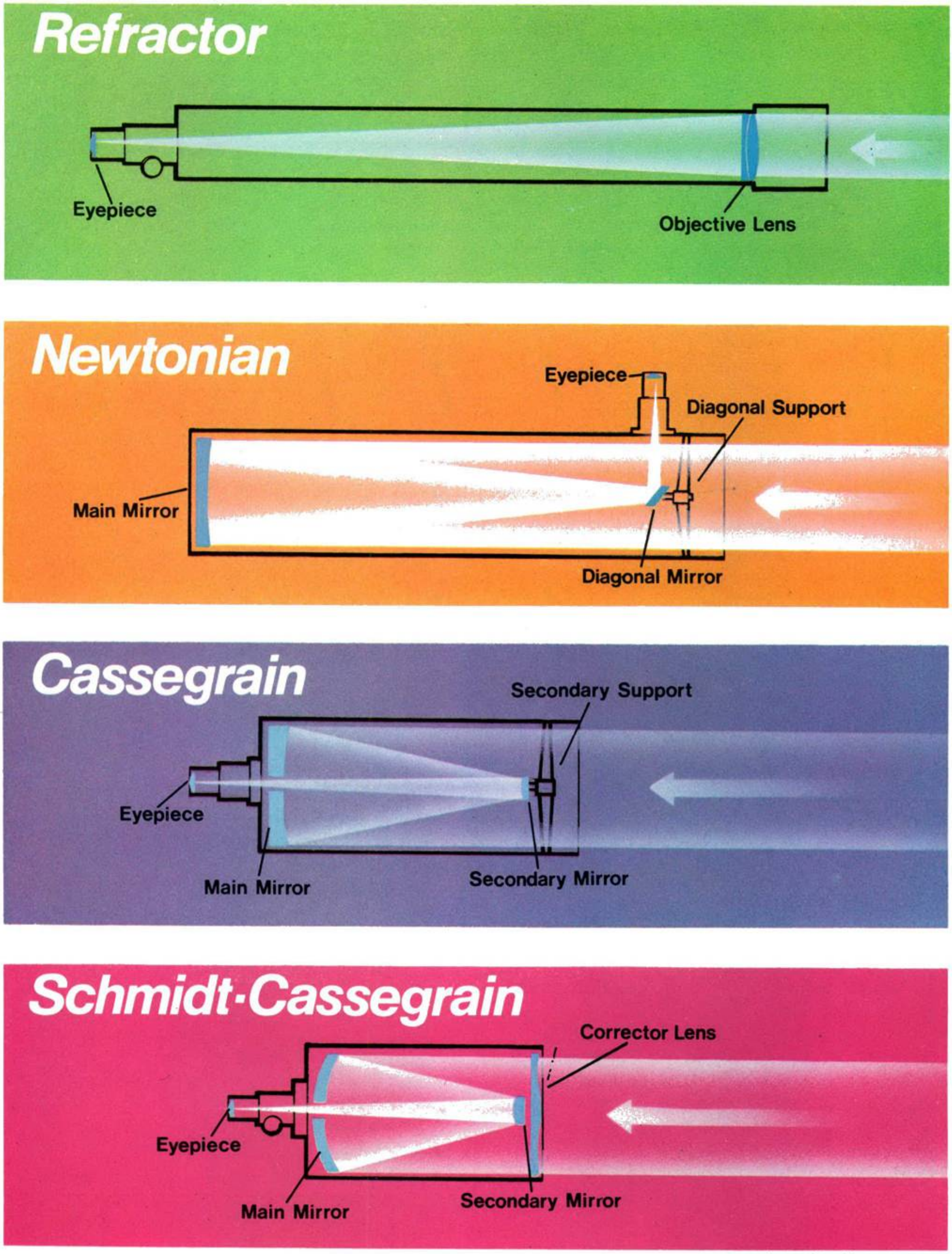
There are, however, some disadvantages. The reflector telescope is open-ended, so the mirror is subject to collection of dust, dirt, or moisture. The mirrors of reflector telescopes can get out of adjustment and require periodic correction; they may also have to be realuminized from time to time to preserve their reflectivity. In addition, reflector telescopes are somewhat more bulky and difficult to use than refractor telescopes. These difficulties, however, can be overcome with a minimum amount of experience in using the telescope, and a good reflector telescope with a mirror ranging from four to six inches will prove to be a thoroughly serviceable instrument. (Reflector telescopes under four inches aperture are often more trouble than they are worth.)

By far the most common reflector telescopes in amateur use are those of the Newtonian design. Another common design for reflector telescopes involves the so-called Cassegrainian system of mirrors invented by a French physician, N. Cassegrain. In a Cassegrainian telescope, the light waves are reflected from the main objective mirror up to a small convex mirror that is suspended in the telescope's tube. This mirror reflects light waves back through a small opening in the middle of the large mirror in order to bring them to focus near the eyepiece. Cassegrainian telescopes can be built with much shorter tubes than Newtonian instruments, and are therefore subject to less vibration from wind or ground tremor. But because the Cassegrainian telescope requires two carefully ground and polished mirrors rather than just one, these instruments are correspondingly more expensive.

What about making your own telescope? A major reason why reflector telescopes are as popular as they are among amateurs is that they are relatively easy to make. Ground, polished, and aluminized mirrors can be purchased ready made from optical supply houses or scientific instrument companies and mounted in a homemade telescope tube with comparatively little effort. It is even possible to grind and polish your own mirror from a glass blank, a less expensive but far more time consuming procedure.

A word of caution is in order, however. Grinding the mirror for a reflector telescope and constructing the telescope to hold it are not excessively complicated, but they do require a great deal of time, patience and craftsmanship. It is an extremely painstaking task and the pains must be taken or a totally useless instrument will result. Before a beginner embarks upon a telescope building project, he should first secure the counsel and, if possible, the active assistance of someone who has actually built a telescope and understands the procedure thoroughly.

For the beginner, the best course is probably to purchase a small telescope and learn to use it to the limits of its capacity. As your interest in your hobby grows, and as you gain in knowledge and experience, you will better be able to evaluate for yourself the advantages and disadvantages of attempting to build a telescope.


Refractor
Eyepiece
Objective Lens
Newtonian
Eyepiece
Diagonal Support
Main Mirror
Diagonal Mirror
Cassegrain
Secondary Support
Eyepiece
Main Mirror
Secondary Mirror
Schmidt-Cassegrain
Corrector Lens
Eyepiece
Main Mirror
Secondary Mirror

Artwork by Victor Costanzo

The light paths of the four main types of telescope optical configurations used by today's astronomy enthusiasts are shown here. A fifth type, the Maksutov, is similar to the Schmidt-Cassegrain.

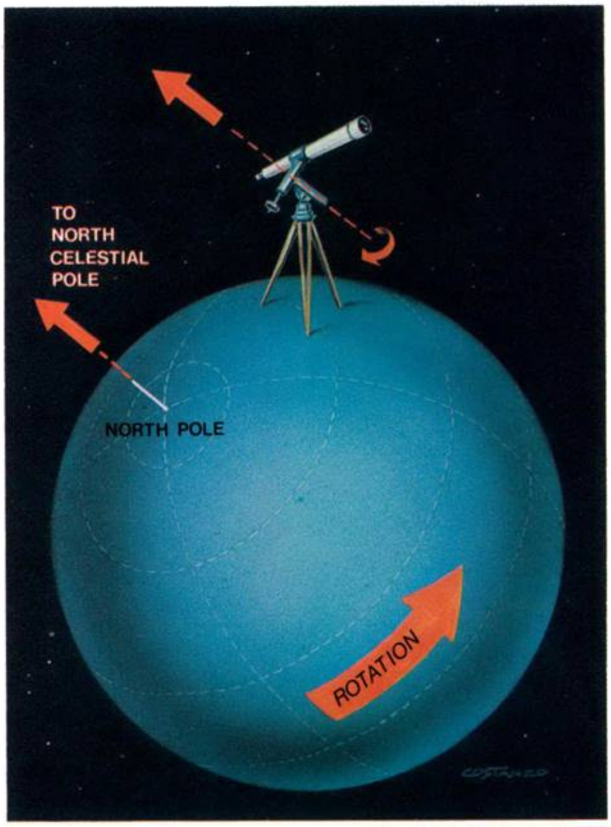
Telescope Mountings

Obviously your enjoyment of telescopic observation will depend greatly upon having a well constructed telescope with good lenses or a good mirror system. What is not so obvious is that an excellent telescope may be virtually useless unless it is properly mounted and supported for comfortable and efficient use. Your telescope must be mounted on a solid footing which will eliminate jiggling and vibration while the telescope is being used. Without a solid footing the slightest breeze will cause vibration of the instrument, with the result that the object you are observing will dance wildly across the field of vision.

A metal camera tripod may be suitable for mounting a small "spotting" telescope, but might prove too shaky for a heavier instrument, Whatever tripod footing you decide upon — whether it is purchased or homemade — test its stability by placing it solidly on the ground or floor, bearing down on the top of it with your hand, and twisting at the same time. If the legs tend to turn with this twisting motion, the tripod is probably too flimsy to be useful and a heavier-duty rig should be obtained or constructed. Once you have a solid tripod, you will then need an adjustable mounting to secure the telescope itself to the tripod head.

Obviously it is not possible to sight the telescope on a celestial object, fix it firmly in position, and then proceed to observe indefinitely. Because of Earth's continuous rotation on its axis, the stars and other celestial objects appear to have a continuous motion across the sky in a great circle around the axis of the north celestial pole. When observing with the unaided eye, you see this motion of the stars as a very slow arc with only the polestar remaining in almost precisely the same position in the sky from one hour to the next. But with the magnification of a telescope, this motion of the stars in the sky means that most objects will very quickly move out of the field of view if the telescope is held in a fixed position.

Thus any mounting you use must be easily and smoothly adjustable so that you can constantly move the telescope to "track" the object you are studying. There are two common types of telescope mountings that can accomplish this goal. The simplest will allow you to move the telescope smoothly and gently in either one or both of two separate axes of rotation: an up and down or vertical axis, so that the telescope can be moved from the horizon straight up across the sky to the zenith (the "altitude" axis), and a horizontal or "azimuth" axis to permit the telescope to be moved from side to side across the sky. This kind of mounting, which really involves a sort of universal joint to permit adjustment of the telescope, is called an altazimuth mount.



Artwork by Victor Costanzo

The equatorial mount is designed to precisely compensate for Earth's rotation. Once the mount's polar axis is aligned toward the north celestial pole (near Polaris), a motor or manual control keeps the scope tracking the star or planet being observed. The essence of this arrangement is that the polar axis of the telescope precisely parallels Earth's axis of rotation. Thus the telescope can aim at a fixed point in space by simply rotating in the opposite direction.

Such an arrangement, simple as it is, has one serious disadvantage. In order to track and observe a given star for any period of time, you must make frequent adjustments of the telescope's position in both the horizontal and vertical directions. Very inexpensive commercial altazimuth mounts are often made with a ball-and-socket clamp or a system of rotating rods and turnscrews which may be very difficult to keep in adjustment. Better made (and correspondingly more expensive) altazimuth mounts are equipped with fine-adjustment knobs that will allow very slight movement of the telescope in each axis of rotation and make it possible for you to follow a given object in the sky quite skillfully with a little practice.

Do not underestimate the importance of a smoothly working solid mounting. With flimsy mounts a very tiny accidental movement of the telescope will often remove the object you are observing completely from the telescopic field so that you will have to search to find it again, a procedure that can be very tedious. If you plan to use an altazimuth mount, or if you purchase a telescope equipped with one, see that it is well lubricated and then plan to spend some time learning to move the telescope slowly and smoothly throughout its entire range of motion in both axes so that, when you are actually star watching, you will be able to make the necessary adjustments almost automatically without accidental jarring or jolting.

One of the major disadvantages of the altazimuth mount — the need for two separate position adjustments — can be avoided by equipping your telescope with a somewhat more complicated mounting, the so-called equatorial mount. As we mentioned earlier, the apparent motion of the stars in the sky is in an arc centering around the north celestial pole. If one axis of your telescope (called the polar axis) can be pointed and fixed directly on the polestar — the one point in the sky that does not seem to move — then any object in the telescope's field of vision can be followed with just one adjustment to move the telescope in the same arc that the stars appear to be following. This principle and the way to set up an equatorial mount are explained in the illustrations on these pages.

With an equatorial mount, you will be able to study celestial objects for prolonged periods with only a single adjustment of the telescope to keep the object within the field of vision. It is sometimes possible to purchase an inexpensive mechanical clock drive to make this adjustment for you so that you will have to pay little or no attention to adjustment while observing. An equatorial mount is decidedly worth the effort to build it if you have an established place from which you will do your observing night after night, or if you intend to use your telescope for astronomical photography since virtually all photographs made through a telescope will require prolonged time exposures. The object you are photographing must be held at the same point in the telescope's field of vision for several minutes if a clear photograph is to result.

In viewing the moon or planets, which have a discernible motion in the sky independent of either Earth's rotation or the apparent motion of the stars, it will be necessary to make additional adjustments to the telescope even with an equatorial mount. But these will be minor compared to those that would be necessary without the equatorial feature.

Accessories for Your Telescope

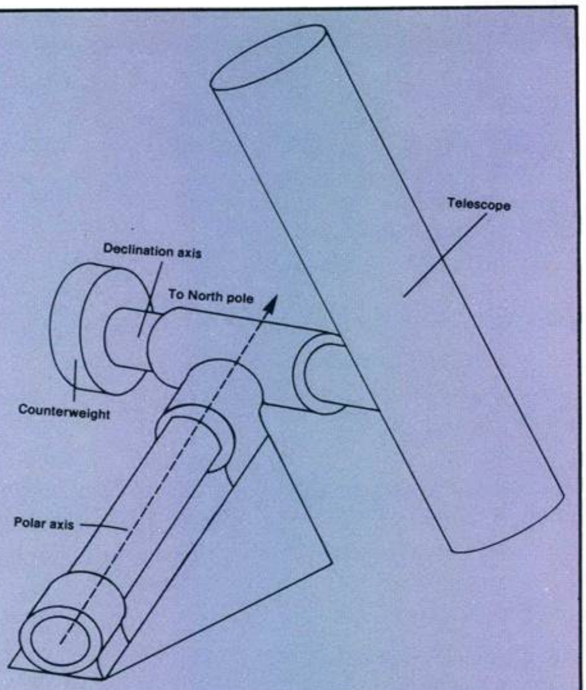
In addition to your telescope, its mounting, and the supportive footing, there are a few accessories that will help make your telescopic observation more simple, comfortable and pleasurable. Most important, perhaps, is a sighting scope (sometimes called a finderscope) attached to the tube of your telescope to help you locate the celestial object you want to observe. The magnified field of vision of your telescope, large as it may appear in the eyepiece, actually represents only a very tiny patch of sky. If you were to use the telescope itself to search for a given celestial object you wanted to observe, you would spend enormous amounts of time and often fail to find the object even at that.

The sighting scope is nothing more than a small, low power spyglass which is bolted to the side of the telescope. The best sighting scopes have six adjustment screws that enable you to precisely position the smaller scope in perfect alignment with the main telescope's optical system. When you have decided what you want to observe with the telescope, the sighting scope can be used to find it in the sky. If the sighting scope is in proper alignment, and if you center the desired object within its field of vision, the object should also be within the field of vision of the telescope itself — or so nearby that it can be found with a minimum of searching.

If you have a refracting telescope, or a Cassegrainian reflector with the eyepiece mounted in line with the telescope tube, you may find a star diagonal prism useful. This is simply a device that bends the light coming through the eyepiece at 90 degrees to the telescope tube so that the viewer can, in effect, look sideways toward the telescope rather than up the length of it.

If you have a good telescope, you will also want at least some choice of eyepieces (ocular lenses) to use for different magnifications. Most telescope eyepieces come in two standard sizes: 0.97 inches in diameter (usually Japanese) or 1-1/4 inches in diameter (for American scopes). Eyepieces of different focal lengths — and usually of different lens construction — can provide low power, medium power, or high power magnification.

Many beginners assume, when first using a telescope, that the instrument will be most useful at the highest magnifying power. But experience will demonstrate that this is not necessarily so. There are many celestial objects which are far better observed under low power than under higher magnification. In examining the surface of the moon, for example, you will find that a low or medium power eyepiece will enable you to see most of the moon's surface in a single field of vision, whereas with higher magnification you would only be able to see a small segment of the moon's surface and would lose much of the three-dimensional quality of the view. Also, the higher the magnification the more swiftly a given object "drifts"



The German equatorial is the most common type of mounting used on refractors and Newtonian reflectors. Although it looks complex, its operation is relatively simple once the polar axis is aimed toward Polaris. For most observing situations this alignment need not be precise.

out of the telescopic field because you are magnifying Earth's rotation too. Thus the lower the magnification you use, the less adjustment of the telescope's position will be necessary as you continue your observation.

A variety of special corrective lenses are also available as attachments to the eyepiece or ocular lens for special purposes. The Barlow lens, for example, which can be attached ahead of the eyepiece, can double or triple the magnifying power of the lens that is in use. Another kind of modifying lens is useful if you wish to use your telescope for viewing objects on the ground as well as in the sky. This is a so-called image erector lens which can be placed ahead of the eyepiece lens to reinvert the upside down image that you would otherwise see through the telescope. Such a modifying lens is of no value for astronomical viewing, however, since it reduces the amount of light coming through your telescope, and the reinversion of the image of celestial objects is of no advantage whatever in observing them.

Finally, if you are interested in experimenting with astronomical photography, you will have to obtain a camera adapter to fit onto the eyepiece tube of your telescope. Standard eyepiece adapters for 35mm cameras are available from scientific equipment companies that advertise in ASTRONOMY.

Purchasing a Telescope

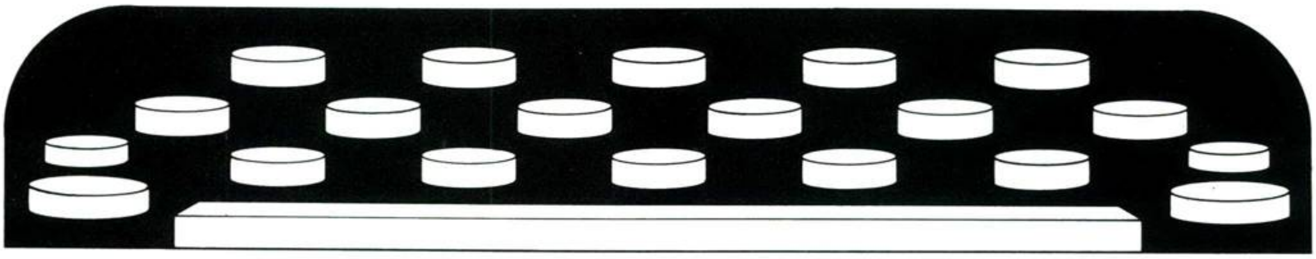
Even a comparatively small telescope will involve a significant investment, and you will want to be as certain as possible that the instrument you are selecting will really meet your needs. Thus you should devote as much time and care to shopping for a telescope as you would when purchasing a camera or stereo set. Small commercially manufactured telescopes, whether refractors or reflectors, are available in a wide variety of sizes and qualities with an ever wider variety of refinements, and you should familiarize yourself thoroughly with what is available at what cost before you make a final selection. Compare prices and features and don't pay any attention to descriptions of a telescope's power — that's only a minor consideration.

It is quite possible to obtain a good used telescope for a much lower price than you would have to pay for a comparable instrument purchased new. Telescopes, especially refractors, suffer little deterioration over the years so good buys are often available. In rare instances it is possible that a used telescope is being offered for sale because it no longer functions properly. In considering any used telescope, especially reflectors, try to arrange to take the instrument for a short period of time on approval before you are committed to buy it, and utilize that time to test its function or have it checked over carefully by some experienced person before you make a final decision.

Whatever your choice, bear in mind that a small and inexpensive instrument may be the best possible selection for your first telescope. Not only can you gain much enjoyment from learning to use it properly, but you will also discover its limitations and disadvantages and can use this firsthand experience — the best counsel of all — later when you seek to buy or build a larger and better instrument.

With a small but serviceable telescope, your exploration of the heavens will take on a totally new and exciting dimension, for the telescope will extend your viewing horizons immeasurably. Not only will you rediscover familiar naked eye and binocular objects in a new richness of detail, but also many other celestial objects will now be observable for the first time. A universe awaits the backyard astronomer.

Dr. Alan E. Nourse has authored numerous astronomy books including **The Backyard Astronomer** *(Franklin Watts, Inc., New York, 1973), from which much of this article has been excerpted.*



IN FOCUS

Sir / I read the article "Observing Double Stars" by Thomas Bretl (May 1974) with interest. Always a popular target for all telescope users, the subject has been one of my projects in a program of comparative analysis while utilizing antique refracting telescopes by Alvin Clark and others.

Since the famous Dawes' limit was established by William R. Dawes in the 1850s with Clark refractors, and enhanced by the great American double star observer S. W. Burnham (who made many of his discoveries at less than 1/2 Dawes' limit), the "re-enactment" of many of these observations has been intriguing to me.

In addition to the suggestions made by Bretl, I would say that patience is the main ingredient! First quality nights are rare and are very often disguised within a "gray" or moonlit night. Also I have noted that on infrequent occasions it will sometimes pay to attempt difficult bright and unequal pairs during twilight or early evening hours. On such occasions if steady atmospheric conditions prevail, the bright sky background will "clean up" the images of these objects and enhance resolution.

With a five inch Clark, I am able to just resolve Eta Coronae which I measure at .59" as opposed to the 0.5" you record. Also, under your "Famous Tests", I find Rigel easy at 100x in a three inch refractor — while on the other hand, Antares provides a good test for a four inch refractor under all but the best atmospheric conditions.

ROBERT B. ARIAIL
Columbia, S.C.

Mr. Ariail / Thanks for your thoughts. Serious double star observers like yourself are a rare breed.

Sir / I am not usually in the habit of writing to a magazine's letter department, but after reading "The Forbidden Moons" in the May issue of ASTRONOMY I felt compelled to do so.

How can you ever come right out and say that man will never walk upon the satellites of Jupiter?! By the time such a spaceflight can take place (say circa 2000 A.D.), technological advancements in many fields will most certainly have been made so that a man can walk upon and explore the surface of any Jovian satellite. He will be wearing a specially developed pressure suit designed to withstand the intense radiation of Jupiter space. There might also be tremendous breakthroughs in the development of drugs that will render man immune to certain levels of radiation.

Who knows? This is all in the future. It's a formidable task, to be sure, but overcoming seemingly impossible tasks is what makes man the kind of animal he is.

Man will indeed walk upon the surface of Ganymede, Amalthea, Callisto, etc. — and probably within the next 30 years!

JACK BRIGGS
Nashville, Tenn.

Mr. Briggs / Obviously we disagree but thanks for your opinion. By the way, if you reread the article you will notice we never did say "that man will never walk upon the satellites of Jupiter." We stated several times the reasons why it seemed highly unlikely in the foreseeable future (i.e. our lifetimes).

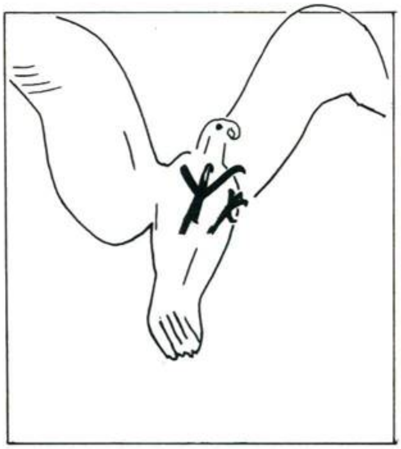
Sir / I found a grievous error in your article on masers in Astro-News (page 44, June 1974). You suggested that methyl alcohol is the essential intoxicant in "white lightning". Not so. The prime intoxicant in "moon" is conventional ethanol. "Jersey lightning", "shine", or even "hair of the dog", as it is sometimes called, is a quite ordinary corn product that is sometimes enhanced with various salubrious ingredients such as lye, strychnine, wood alky, etc., to bring out qualities such as body, bouquet, aroma, character and kick — but many processors and purveyors rely solely on intrinsic values so as to allow the product to stand on its own merits.

I really believe that you have committed a grave injustice to reliable providers for the trade.

AL LOVITZ, Ph.D.
Urbana College
Urbana, Oh.
(Misplaced West Virginia)

Sir / The beautiful nebula on the cover of the April issue of ASTRONOMY looks like a golden eagle. My dad made this sketch to show what I mean. I think that M-16 should be called the Eagle nebula.

KIMBERLY MOE (age 9)
Irvine, Calif.



Miss Moe / Surprisingly, other readers also thought M-16 should have the name you chose. We may very well have taken this nebula from the dull realm of numbers.

Sir / In a recent magazine article I read about a galaxy called a Seyfert Galaxy. I looked it up in my back issues of ASTRONOMY, encyclopedias and dictionaries and couldn't find the meaning of "Seyfert". Could you tell me what a Seyfert Galaxy is? Thank you.

DAVID PIECYK
Bellmawr, N.J.

Mr. Piecyk / Seyfert galaxies were named after Karl Seyfert who was the first to study them in detail. A Seyfert galaxy is characterized by its small bright almost star-like nucleus. They are of no interest to amateur observers but they may be related to quasars and thus be important to our understanding of the universe. A major article on galaxies is coming up later this year in ASTRONOMY.

Sir / I think ASTRONOMY is destined to become an institution among astronomical periodicals. The articles are well written for readers with a variety of astronomical backgrounds (my nine year old bombarded me with questions after reading parts of "Life on a Neutron Star" in the December issue) and the photographs and artwork are splendid. My high school astronomy students find the articles extremely interesting and are not discouraged as they have been with some other scientific periodicals.

JOHN C. POGUE
Grand Prairie, Tex.

Sir / I must compliment you on the superb and outstanding photography and artwork in the June, 1974 issue. From Vic Costanzo's cover drawing, all the way through to his depiction of the positions of the planets in the evening sky on page 53, the realism of his work is breathtakingly beautiful.

The NASA pictures of the planets, particularly Jupiter, are also "out of this world". Which brings up the point of this letter.

On page 27, Jupiter is shown with the shadow of Io. Realizing that the moon which made that shadow was leading the shadow, I felt that Io itself must be in the picture. So, by looking intently at the extreme right edge of the planet, and just below a brownish oval shaped smudge, there is an almost perfect disc. It is about the same size as the shadow, and I feel it is a possibility that the photograph captured not only Io's shadow, but Io, also.

In looking back, then, at the photo on page 24, with the magnificent view of the red spot, one can see a round bright disc against the darker background of the shadowy area of Jupiter — just an inch or so to the left of the spot. Could this also be a moon? Is it possible that this speck seen from only 616,000 miles from Jupiter might be the tiny moon JV? It seems to be too large, actually, since that moon would be only 1/ 250 the width of the red spot. So my curiosity is whetted — what might it be?

On the subject of moons of Jupiter, the painting by Ron Miller on page 26 is very interesting. Of course, the halo around a large moon would not be larger than the halo around a small moon — both being caused by reflections from ice crystals.

VICTOR A. WAGNER, JR.
Wilmette, Ill.

Mr. Wagner / Thanks for your compliments and observations. Sorry to disappoint you, but no moons are seen on the Jupiter photos in the June issue — only the shadow of Io. The light oval on page 27 is only a cloud formation and the smudge on page 24 you refer to is a photo flaw that originated in the spacecraft's data transmissions. You are quite right, Ron Miller did express artistic license in his painting; both halos would actually be the same size.

Letters intended for this column should be addressed to The Editors of ASTRONOMY. We are sorry but the volume of mail does not permit individual replies.

JULY

Stars in each constellation are indicated, in order of brightness, with the Greek Alphabet.

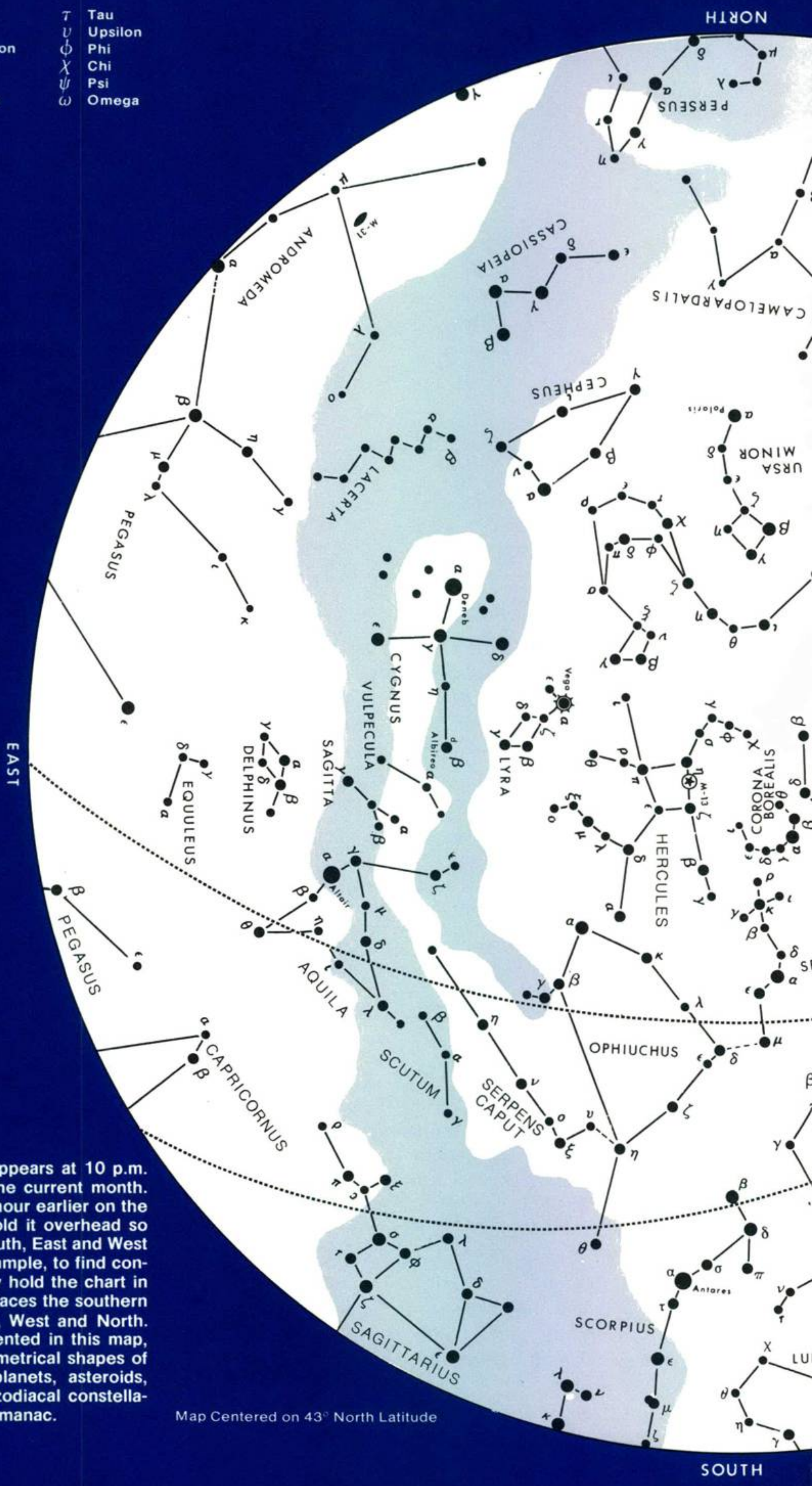
α	Alpha	η	Eta	ν	Nu	τ	Tau
β	Beta	θ	Theta	ξ	Xi	υ	Upsilon
γ	Gamma	ι	Iota	o	Omicron	ϕ	Phi
δ	Delta	κ	Kappa	π	Pi	χ	Chi
ϵ	Epsilon	λ	Lambda	ρ	Rho	ψ	Psi
ζ	Zeta	μ	Mu	σ	Sigma	ω	Omega

MAGNITUDES

- ✹ Zero
- ● First
- ● Second
- ● Third
- • Fourth
- • Fifth

OBJECTS

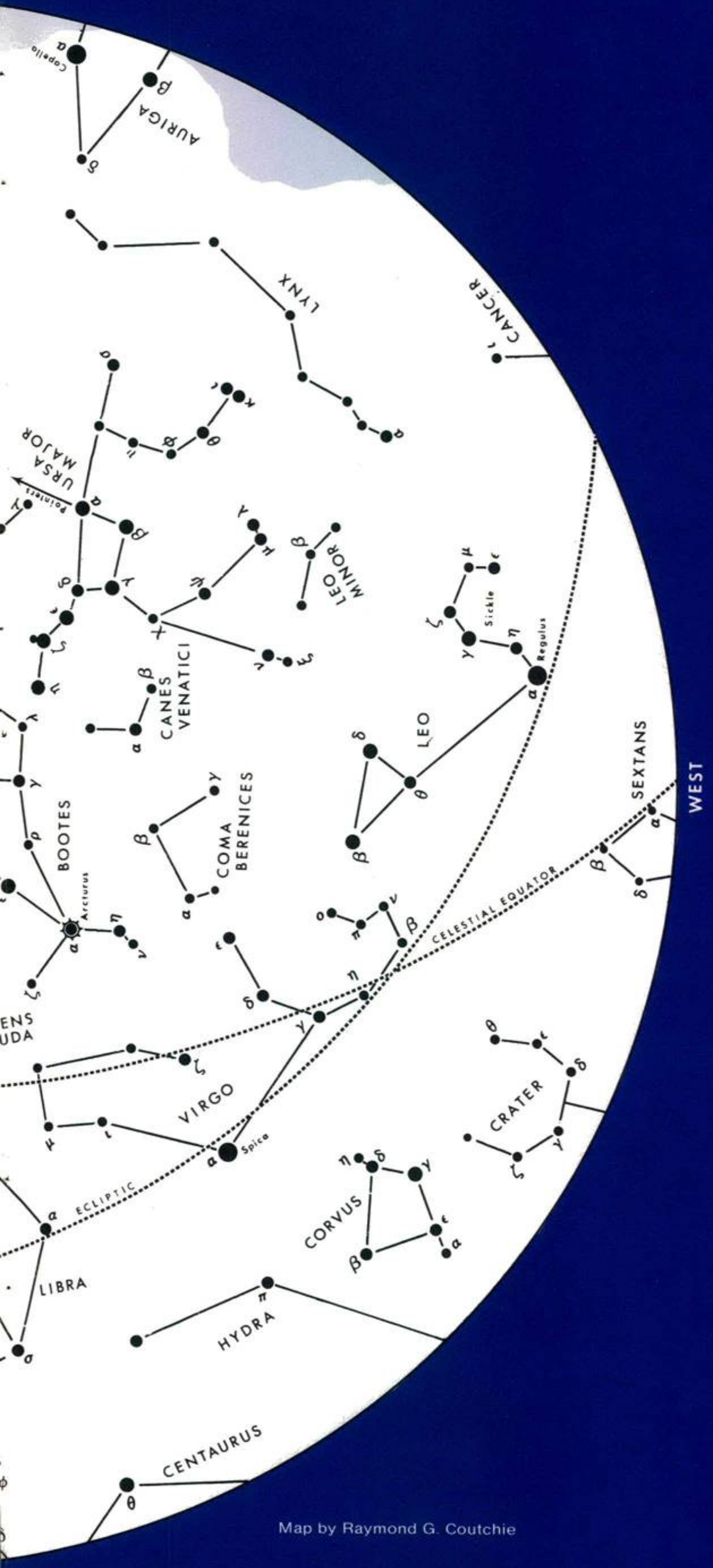
- ★ Open Clusters
- ⊛ Globular Clusters
- ○ Diffuse Nebulae
- ⬬ Galaxies
- ●d Double Stars
- ●v Variable Stars


NORTH
PERSEUS
CASSIOPEIA
CAMELOPARDALIS
ANDROMEDA
M-31
CEPHEUS
Polaris
URSA MINOR
LACERTA
PEGASUS
Deneb
CYGNUS
VULPECULA
Vega
Albireo
LYRA
SAGITTA
DELPHINUS
EQUULEUS
HERCULES
M-13
CORONA BOREALIS
EAST
Altair
PEGASUS
AQUILA
SCUTUM
SERPENS CAPUT
OPHIUCHUS
CAPRICORNUS
Antares
SCORPIUS
SAGITTARIUS
SOUTH

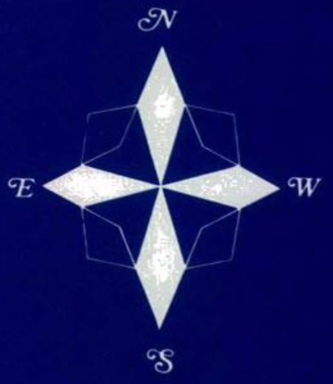
Map Centered on 43° North Latitude

Star Dome approximates the sky as it appears at 10 p.m. Local Daylight Time on the first day of the current month. The same constellations are visible one hour earlier on the 15th. To use this constellation finder, hold it overhead so the compass points line up with North, South, East and West in your backyard or viewing area. For example, to find constellations in the southern part of the sky hold the chart in front of you so the South compass point faces the southern horizon. Repeat this procedure for East, West and North. Since only the brighter stars are represented in this map, you should be able to trace out the geometrical shapes of the constellations with ease. To find planets, asteroids, etc., visible among the current month's zodiacal constellations, refer to the planet finder in Sky Almanac.

STAR DOME


AURIGA
Capella
LYNX
CANCER
URSA MAJOR
Pointers
LEO MINOR
Sickle
Regulus
CANES VENATICI
LEO
SEXTANS
WEST
BOOTES
Arcturus
COMA BERENICES
CELESTIAL EQUATOR
ENS
UDA
VIRGO
Spica
CRATER
ECLIPTIC
CORVUS
LIBRA
HYDRA
CENTAURUS

Map by Raymond G. Coutchie



As darkness descends to cool a hot summer afternoon the myriad stars are there, just the way they were in Greek or Roman times. One heritage of those vanished cultures is the constellations — groupings of stars named for mythological characters and animals.

High in the evening sky this month is Hercules, a constellation named for the Greek hero famous for his singlehanded slayings of dragons and various monsters. Hercules was the son of the god Jupiter and a mortal woman, a background that undoubtedly was responsible for his inhuman strength.

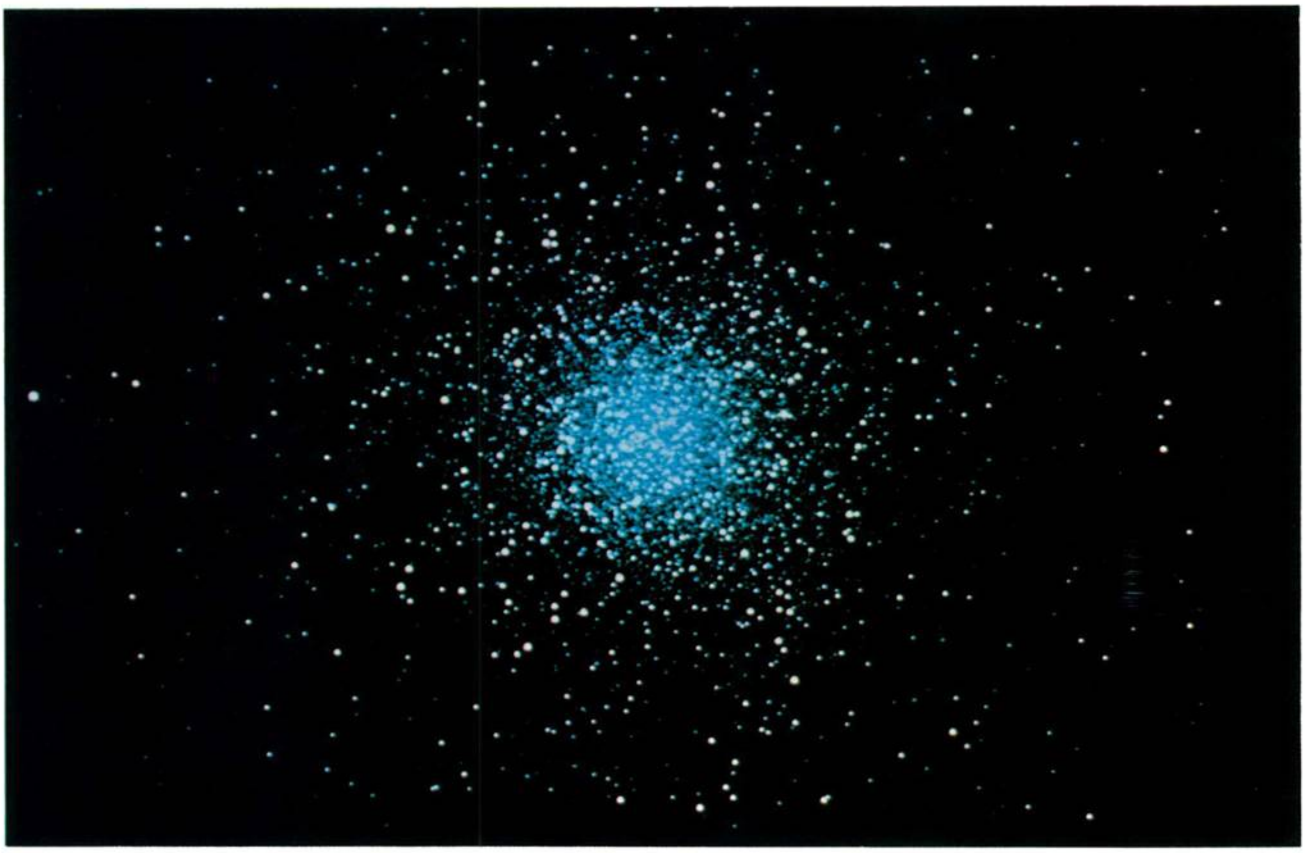
Jupiter's immortal wife, Juno, was rather upset by Hercules' appearance on the scene (evidencing Jupiter's infidelity). After sending a few monsters, which Hercules dispatched with ease, Juno decided more severe action was necessary to vent her distaste for the strong man.

Casting a spell on Hercules to make him temporarily insane, Juno watched with satisfaction as he murdered his wife and children. As penance for this deed Hercules was punished by his famous 12 labors.

His first encounter was with a huge lion. The lion was so tough that arrows bounced off its hide. As a last resort Hercules began strangling the animal but they were so evenly matched that it took the muscle man 30 days to kill the beast. The lion now rests to the west of Hercules as the constellation Leo.

Next was a battle with Hydra the water snake. Hercules won of course and Hydra too shares the sky with Hercules on spring evenings. The third through the eleventh labors of Hercules have little to do with sky mythology.

For the twelfth labor it was Hercules' task



U.S. Naval Observatory Photograph

This colossal sphere of one billion stars, over 20,000 light-years distant, is known as M-13 or simply the Hercules cluster. All the stars seen in this photo are several hundred times more luminous than the sun. A star like our sun would be totally undetected. To the unaided eye this cluster is barely visible as a hazy star in Hercules.

to secure the golden apples from a tree protected by Draco the dragon. Draco was truly a formidable opponent. He never slept, his breath was like a military flame thrower and his skin was as tough as steel-belted radials. Hercules soon discovered the dragon was too much for him so he went to Atlas for assistance. Atlas, a true god, easily got the apples but became distracted with mortal goings-on. Meanwhile he had Hercules take over his job of holding up Earth.

Hercules finally got Atlas' attention and asked him if he wouldn't mind holding Earth long enough for Hercules to get a shoulder pad to ease the burden. Once Atlas hoisted Earth on his shoulder, Hercules grabbed the apples and ran.

Juno, who had sent Draco to guard the apples in the first place, condemned the hapless dragon to circle the sky forever. So Draco joins our merry band of characters in the summer sky.

If you enjoy our legends about the sky you may want to get a copy of Star Myths and Stories by Percy M. Proctor (Exposition Press, N.Y., 1972, $6.00). In a delightful style Proctor tells the legends connected with the major constellations. The book's mediocre star maps are a minor detraction from an otherwise well conceived summary of this quaint heritage. Our only criticism is that we wish Proctor had dug up more legends — the 183 pages go too quickly.

We haven't mentioned much about finding your way among the summer stars. Last month we located the faint stars of Hercules and tried to zero in on M-13, the famous globular cluster shown in all its magnificence on this page. However to the south of Hercules is sprawling Ophiuchus (pronounced oh-fee-YOU-kus) and the equally obscure two-part constellation of Serpens. Finding your way gets tough. Give it a try — if you have trouble we'll be back next month to help.

ANNOUNCING

Custom Framed Lithographs From ASTRONOMY

The photographic expertise of Orien A. Ernest and talented imagination of artist Victor Costanzo combine in a unique new lithograph offer from ASTRONOMY.

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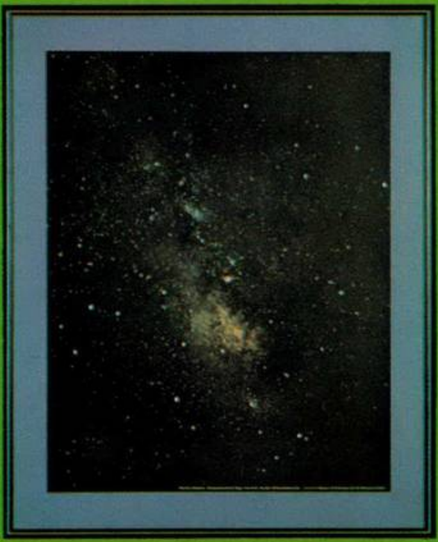

Milky Way in Sagittarius

The detailed cover photograph of ASTRONOMY's March issue is now a colorful, 17 x 22 inch blow-up poster. A host of celestial objects at our galaxy's core are recorded in full color in this breathtaking photograph by Orien A. Ernest. The gossamer, golden beauty of the Sagittarius star clouds is revealed in magnificence unsurpassed by any other color Milky Way photograph. This beautiful lithograph is available framed as above or unframed.

Unframed Lithographs:

Milky Way in Sagittarius or **Mars as Seen From Deimos** may be purchased individually or as a set. Unframed lithos are rolled (not folded) and shipped in a mailing tube marked "Special Handling". Posters measure 17 x 22 inches in size.

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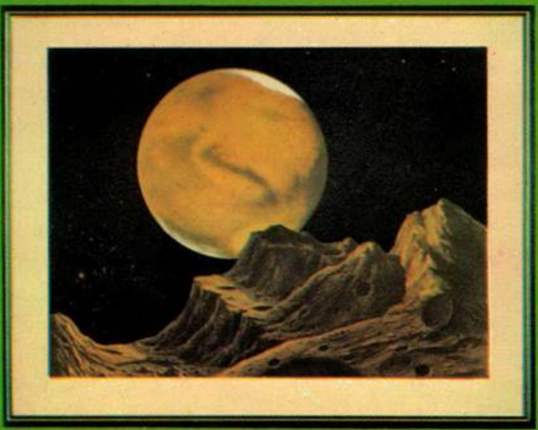


Mars as Seen From Deimos

The artistic imagination of Victor Costanzo is boldly displayed in this 17 x 22 inch full color lithograph of the red planet Mars as it would appear from its outer satellite Deimos. Costanzo's painstaking accuracy in this rendition is given further credence because he incorporated real constellations in the sky background. To the lower left of the planet is the Hyades star cluster in Taurus, and to the upper right is the constellation Aries. This artwork was first used as a two page spread in ASTRONOMY's May issue to illustrate "The Lost Pictures of Mars" by Carl Sagan. It is available framed as above or unframed.

CONSTELLATION CLOSE-UP

Sagittarius

by
Thomas C. Bretl

On a clear summer evening you can comfortably pause to look toward the very center of our galaxy, hidden behind the constellation Sagittarius. Dark clouds of dust and gas effectively hide much of this galactic nucleus, but the unobscured "local" wonders which lie in that direction are among the most beautiful to be found anywhere in the heavens. Color photographs of the region (such as the March cover photo by Orien Ernest) dramatically reveal an amazing wealth of telescopic attractions — numerous and varied globular clusters, magnificent diffuse nebulae, and rich open clusters almost lost in the brilliance of the surrounding Milky Way.

Sagittarius contains more Messier objects than any other constellation, and seven of these form an interesting assortment of prominent globular clusters. Individually all are excellent objects for small telescopes, and as a group, they are sure to dispel the idea that most globulars have exactly the same appearance. Some are large and loosely structured groups of stars, easily resolved, while others are extremely compact clusters with diameters of only a few minutes of arc. Here is an excellent opportunity to experiment with a wide range of magnifications and make your own study of a marvelous class of objects; in particular, it is interesting (and challenging) to see how many of these brilliant hazy balls you can resolve into individual stars, thus revealing their true nature.

Two degrees northeast of Lambda Sagittarii is M-22, one of the largest and most impressive of all globular clusters. At sixth magnitude, it lies just at the threshold of naked eye visibility as a faint, fuzzy spot — but in a telescope it becomes a bright, sparkling mass of stars which extends to a diameter of more than 15 minutes of arc. Webb (in **Celestial Objects for Common Telescopes**) describes M-22 simply as beautiful and bright. He also notes that because of the brightness of its individual stars, it is a particularly good object for small telescopes. That brightness, combined with the cluster's large size and rather loose struc-

TABLE OF OBJECTS IN SAGITTARIUS

Open Clusters

NGC	Messier Object	Mag.	Size	R.A.	Dec.
6494	M-23	7	27'	17^h55^m	-19°01'
6531	M-21	7	10'	18^h03^m	-22°30'
6603	M-24	5	4'	18^h17^m	-18°26'
6613	M-18	8	12'	18^h18^m	-17°08'
I4725	M-25	7	40'	18^h30^m	-19°16'

Globular Clusters

NGC	Messier Object	Mag.	Size	R.A.	Dec.
6626	M-28	7	4.7'	18^h23^m	-24°53'
6637	M-69	8	2.8'	18^h29^m	-32°22'
6659	M-22	5	17.3'	18^h34^m	-23°57'
6681	M-70	8	2.3'	18^h41^m	-32°20'
6715	M-54	7	2.1'	18^h53^m	-30°31'
6864	M-75	8	1.9'	20^h04^m	-22°01'
6809	M-55	6	15.0'	19^h38^m	-31°00'

Diffuse Nebulae

NGC	Messier Object	Mag.	Size	R.A.	Dec.
6514	M-20	9	27'x29'	18^h00^m	-23°02'
6523	M-8	6	35'x60'	18^h02^m	-24°20'
6618	M-17	7	46'x37'	18^h18^m	-16°11'

Epoch 1970

ture, explains why M-22 is well resolved into countless pinpoints of light when viewed through a six inch telescope.

Seen through larger instruments, M-22 is truly a fantastic sight. A 12 inch telescope reveals a rather widely scattered layer of clearly resolved 11th magnitude stars which seem to lie on top of a softly glowing backdrop of much fainter and more concentrated 15th magnitude ones. In any telescope, however, M-22 is almost sure to live up to its usual star atlas billing: "This one is magnificent."

The area near Mu Sagittarii is a rewarding place to sweep at low power as well as to hunt for individual objects. So rich is this region that some of the open clusters are almost lost in their own background. Starting with M-8, the Lagoon nebula, one can sweep north on a line parallel to the galactic equator past M-20, the Trifid nebula; open clusters M-21, NGC-6568, M-24, and M-18; M-17, the Omega or Horseshoe nebula, and all the beautiful star fields in between. Here the patterns of the stars and dark nebular clouds which obscure them are both obvious and curious, and it is this visible structure of the entire region which makes Sagittarius such an extraordinary place to spend some time.

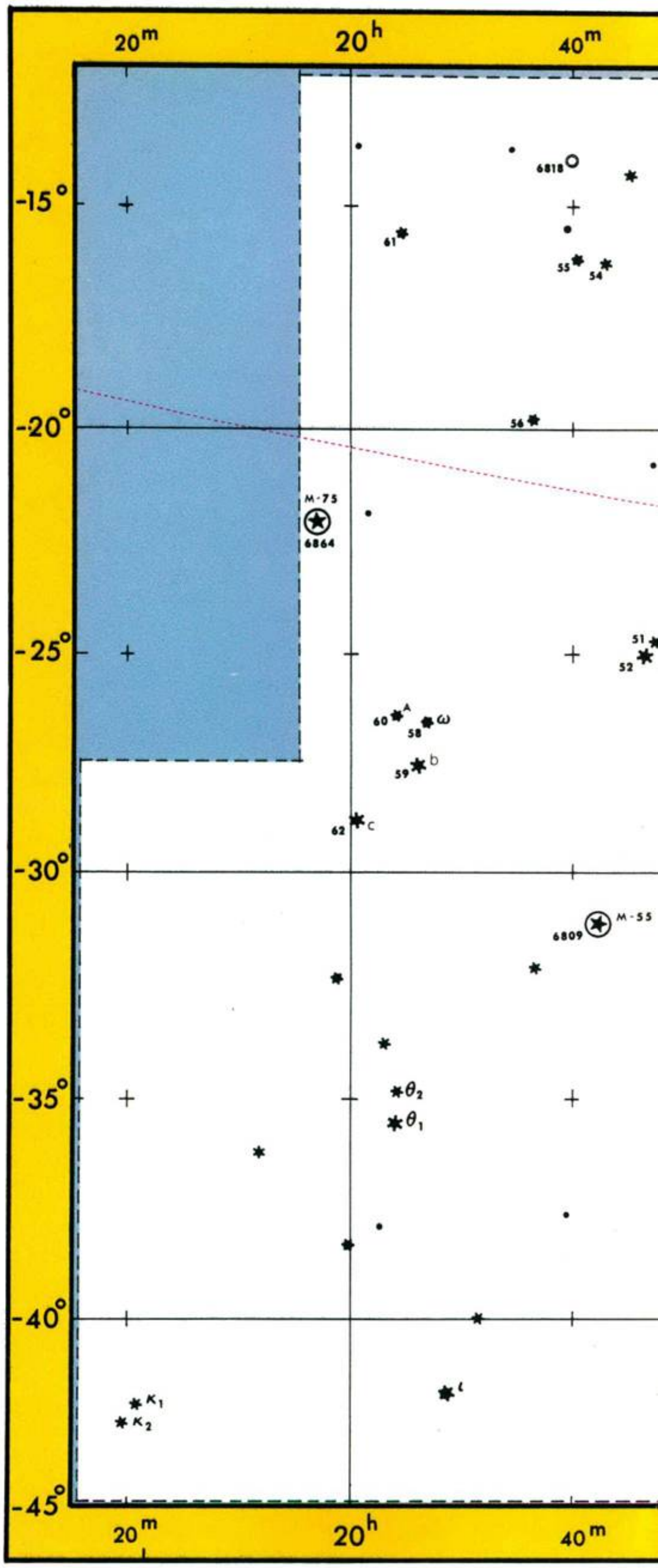
In particular, northwest of Mu (between M-23 and M-24), is a spot where the brighter stars are found in amazing geometric patterns, patterns "so geometric," wrote Sestini (as quoted by Webb), "that it is impossible to think that it is accidental. Most of them are like spiral arcs...following a curve like the beads of a rosary. Others form rays which diverge from a common center, and what is particularly striking is that when you look at the center of these rays or the beginning of the branch of a curve, you usually find a bright red star." It is easy to find this "patterned area", and once you find it you will surely agree that Sestini's description is not at all an exaggerated one. There are few places in the sky where such patterns stand out so clearly.

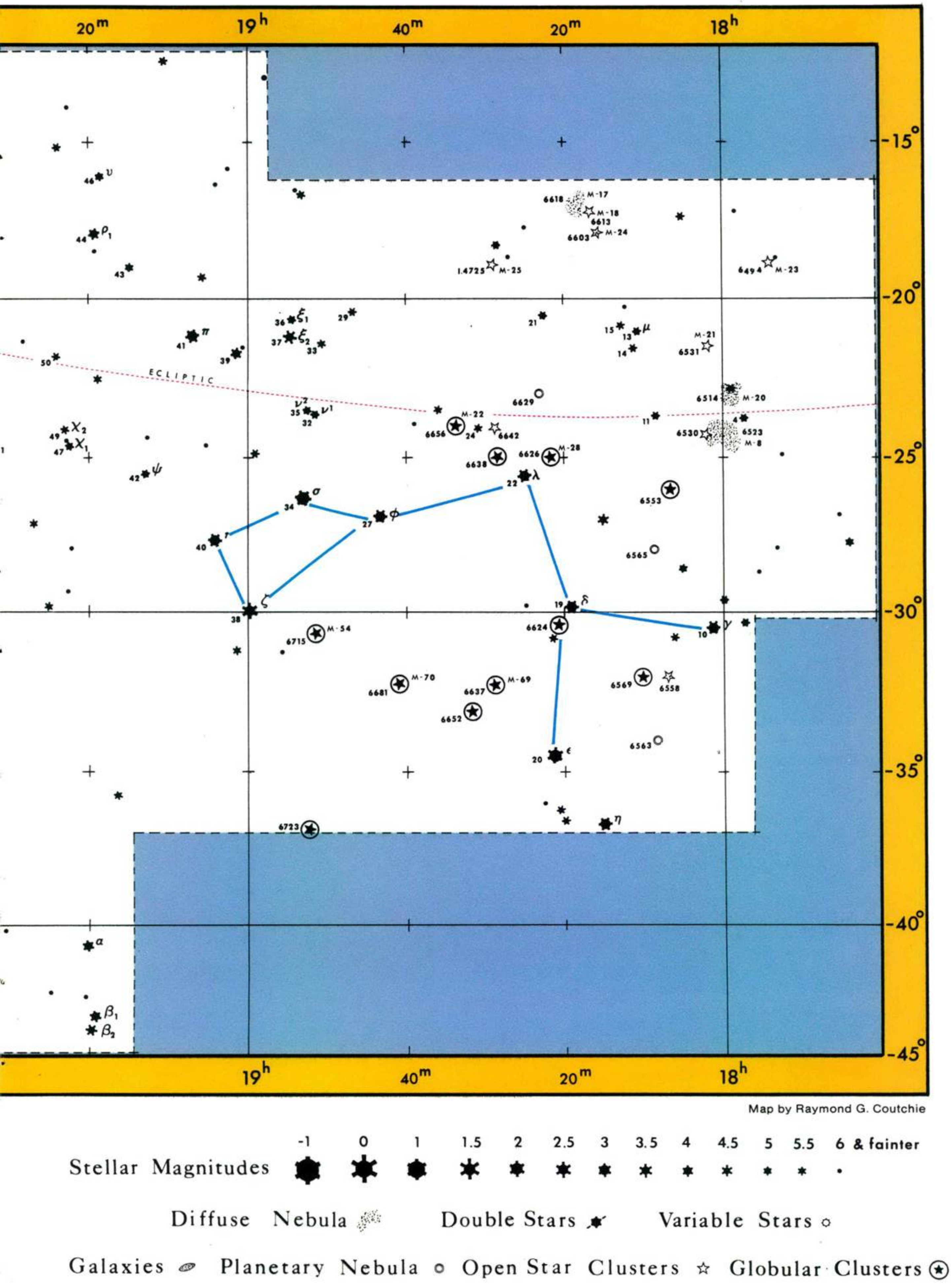
In addition to the overall large scale beauty of this part of Sagittarius, some of the individual objects found here are so impressive that they definitely deserve some close attention. M-8 and M-20 are two such objects. These well-known diffuse nebulae have probably been photographed as often as any other deep sky objects, and although the fantastic colors which are so striking in those photos cannot be detected visually, these bright clouds of glowing gas are beautiful in "telescopic black and white" as well. On nights of good seeing, an eight inch telescope will bring out much intricate and delicate detail in both nebulae. In particular, look for the dark rifts in the Trifid nebula (M-20) which divide it into three parts and thus give it its name, or investigate the many dark lanes and "celestial cloud banks" of the Lagoon (M-8). As in the case of the Great Nebula in Orion, you will probably be amazed by the great area both these nebulae span; their nebulosity, however faint, extends outward a much greater distance than may appear at first glance.

M-17, the Horseshoe or Omega nebula, is the third remarkable diffuse nebula in Sagittarius. Despite its prominence, however, not much attention is usually given to it; little mention of it is made in most books, and photographs of it are seldom seen. Nevertheless it is perhaps the most striking object of the three, as viewed through a small telescope. Although approximately the same total magnitude as M-20 and M-8, M-17 seems to stand out much more boldly than either of them. Instead of "blending in" with its surroundings, it is just "suddenly there" and contrasts sharply with a dark background sky. Its shape, too, adds to its startling appearance; it has been described as "L" or "2" shaped, but neither description really does it justice. It is unusual and irregular, has an air of mystery about it, and is sure to surprise you the first time you see it.

Sagittarius is so full of beautiful star fields that it seems unnecessary and futile to begin describing its individual galactic clusters. For example, the "star cloud" just north of Mu (which will appear as a large fuzzy patch in your finderscope) is so rich that it is much more impressive than most bona fide clusters in other parts of the sky. M-24 lies right near the edge of this cloud and is an extremely rich open cluster — more than 50 stars are contained in an area only four minutes of arc across! Yet it is almost engulfed by the fantastic "mega-cluster" which surrounds it. Indeed, you must look carefully to find it at all!

Again it is the richness and beauty of the entire region which draws our attention and captures our imaginations. On a clear dark night the view of the southern Milky Way is as incredible to the naked eye as any single object is when seen through the powerful, yet somewhat restrictive eye of the telescope. Use binoculars or your lowest power eyepiece this month and sweep slowly north and south of Mu. You will "accidentally" discover most of the objects listed in this month's table anyway, but you will also find many things that are not listed at all. Here in Sagittarius, the whole is equal to much, much more than the sum of its individual parts!




20m
19h
40m
20m
18h
-15°
-20°
-25°
-30°
-35°
-40°
-45°
ECLIPTIC
46 υ
44 ρ1
43
41 π
39
36 ξ1
37 ξ2
33
29
50
49 χ2
47 χ1
42 ψ
35 ν2
32 ν1
34 σ
27 φ
40 τ
38 ζ
22 λ
19 δ
10 γ
20 ε
η
α
β1
β2
21
15
13 μ
14
11
4
6618 M-17
M-18
6613
6603 M-24
1.4725 M-25
6494 M-23
M-21
6531
6514 M-20
6530
6523
M-8
6629
6656 M-22
24
6642
6638
6626 M-28
6553
6565
6624
6715 M-54
6681 M-70
6637 M-69
6652
6569
6558
6563
6723

Map by Raymond G. Coutchie

Stellar Magnitudes
-1
0
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6 & fainter
Diffuse Nebula
Double Stars
Variable Stars
Galaxies
Planetary Nebula
Open Star Clusters
Globular Clusters

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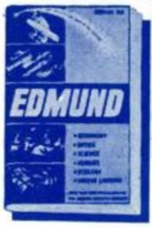

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